THE ENGINEER

A Seven-Day Journal

Cars for the Home Market

The Ministry of Supply has stated this week that the number of new cars for the home market in 1952 is to be limited to 80,000. The Ministry says that the needs of the defence programme will bring about a progressively greater use of the motor industry's capacity for the production of vehicles for the armed forces and this must be at the expense of production of civilian vehicles. Furthermore, the motor industry's total output will continue to be limited by the shortage of raw materials. At the same time, however, motor vehicle exports must be maintained at as high a level as possible. The Ministry has accordingly informed the Society of Motor Manufacturers and Traders that, for the calendar year 1952, the number of new cars for the home market will have to be limited to 80,000. The home quota for 1951 is 80,000 cars, plus half of any production in excess of 460,000 cars. So far this year the output of cars has been at an annual rate slightly below 500,000, which, if maintained, would give a ceiling release rate of 100,000 to the home market.

Mr. David M. Watson's Retirement

It has been announced this week that Mr. David Mowat Watson, B.Sc., M.I.C.E., has retired from partnership in the consulting firm of Messrs. J. D. and D. M. Watson, of Westminster, with which he has been associated for the last thirty-two years. Mr. Watson, who was born in Aberdeen in 1891, was educated at Bishop Vesey's Grammar School, Sutton Coldfield, and at Birmingham University. He began his professional career as an assistant to the late Mr. George A. Hart, M.I.C.E., of Leeds, and then worked for a period with Hering and Gregory, of New York. In 1919, Mr. Watson joined the consulting firm which had been established by his father, the late Mr. John Duncan Watson, a past-president of the Institution of Civil Engineers. During his years of practice he has advised on, designed and supervised the construction of many sewerage works and main drainage and water supply schemes for governments and local authorities at home and abroad. Mr. Watson became an associate member of the Institution of Civil Engineers in 1918 and was transferred to full membership in 1931. He is a Member of Council and a Telford Gold Medallist of the Institution. He is also a past-president of the Institution of Sanitary Engineers, a past-chairman of the Association of Consulting Engineers, a past-chairman of council and vice-president of the Royal Sanitary Institute, and Colonel Engineer and Railway Staff Corps, R.E. Although he is relinquishing his partnership, Mr. Watson is being retained by his firm as a consultant.

The Model Engineer Exhibition

The Model Engineer Exhibition, which was opened on Wednesday last, August 22nd, at the New Royal Horticultural Hall, Westminster, will remain open daily until Saturday, September 1st. As in previous years, hundreds of models of all kinds are exhibited and a number of interesting demonstrations have been arranged by the organisers. For the first time motor racing with authentic scale models has been introduced on a miniature Grand Prix track consisting of straight, right and left-hand bends, climbing and descending turns, &c. On this track visitors can see true-to-scale models racing three at a time. A tank has been installed in the marine section of the exhibition, and in it radio-controlled models of vessels, speedboats and sailing boats are being demonstrated. Another radio-controlled model is an airship, 12ft 6in long, powered by a small internal combustion engine. This year the principal model railway working exhibit has been constructed by the Ilford Model Railway Club and the lay-out includes up and down roads, a passing station, goods yard and locomotive shed, a stopping station, &c. Although these demonstrations provide good entertainment, they in no way detract from the interest which all visitors cannot fail to take in the many ambitious and ingenious models to be seen on every hand. In all the exhibits, from the simplest to the most complicated true-to-scale radio-controlled units, there is no sign of any decline amongst model makers of the high standard of craftsmanship, adaptability and originality for which the entries at this exhibition have been noted for so many years.

Fire Research in 1950

The annual report of the Joint Fire Research Organisation of the Department of Scientific and Industrial Research has now been published. It contains details of fire hazards in homes, industrial buildings and warehouses, and of improved methods of fire fighting. In a section devoted to building, the report discusses the fire incidence rate of post-war houses of traditional and non-traditional design and of the increased rates of fire propagation in these dwellings. Studies of the ignition of combustible materials and the spread of flames over their surfaces, and of the effect of treatments in retarding these processes were continued last year. A comparative examination of the results of all the tests so far made in this country on timber beams and floors has led to the development of a formula that will give with reasonable accuracy the fire endurance of any common size of timber joist under specified loading conditions. References to new fire-fighting equipment and technique include work done on various kinds of water sprays. Tests have shown that the efficiency of the sprays depends on the size of the drops produced in them. Improved equipment for producing drops of the most effective size has been developed. Experimental work has been carried out on particular hazards, such as the hazard of tanks or drums which have contained inflammable liquids which do not appear to have been regarded as dangerous, and of sparks caused by the use of certain kinds of aluminium paint on rusty iron.

The Dome of Discovery

In a letter published in *The Times* on Wednesday last, Mr. Robert Chalmers, president of the Engineers' Guild, has expressed the hope that the Dome of Discovery at the South Bank Exhibition will not be lost to the nation when the exhibition ends on September 30th. The letter points out that the structure, which is of comely and distinguished appearance, can provide cover for an area of 10,000 square yards, completely clear of obstruction by internal supports, with a clear height of from 45ft to 90ft. Such unexampled achievements, Mr. Chalmers says, were possible only because the engineers devised a completely original structural framework in which the respective qualities of recently developed aluminium alloys and of welded structural steel were combined in one scientifically integrated design. The present internal structures, the letter continues, serving the purposes of the exhibition, are unlikely to be useful elsewhere and could not be transferred. In the engineering design of the dome itself, however, careful provision was made for the greatest possible ease of dismantling and re-erection. Both for the numerous useful purposes that it could be made to serve, and as a happy demonstration of British skill—in the architectural profession by its imaginative conception, in the engineering profession by the originality of its structural design, and in the engineering industry by its high quality of workmanship and speedy construction—this unique achievement of 1951, Mr. Chalmers considers, is surely as worthy of a permanent place in our national life as was the Crystal Palace of 1851.

Shipping Casualties

The Ministry of Transport's returns of shipping casualties in 1949 have been published this week by H.M. Stationery Office. They show that 60,276 gross tons of shipping were lost, 59,993 tons of which included vessels of 100 tons gross and over. It is stated that the total was nearly twice that of 1948, but was about equal to that of 1947. The returns for 1949 include the "Magdalena," of 17,547 tons, which stranded on her maiden voyage. Of the cargo ships of 100 tons gross and over, lost during 1949, sixteen, aggregating 39,972 tons gross, were carrying cargo, and two, aggregating 2474 tons, were in ballast. The total loss for the year, the returns explain, represented 0·34 per cent of the total tonnage on the register at December 31, 1949. The number of power-driven vessels of 100 tons gross and over which were seriously damaged during the year was 117, of 321,357 tons, compared with ninety-two, of 367,427 tons in 1948.

The Engineering, Marine and Welding Exhibition

On Thursday next, August 30th, the Engineering, Marine and Welding Exhibition will open at Olympia, and it will be open daily until Thursday, September 13th. This exhibition, which has been held every two years since 1906—apart from the two war periods—gives British engineering firms an opportunity to show their most recent developments to potential buyers from home and overseas, and is one of the important events in the engineering calendar. The exhibits will cover a representative range of products from the engineering, marine and allied trades, including industrial and marine engines, process plant and equipment, electrical apparatus, constructional plant, foundry plant, welding equipment, forgings, castings, ferrous and non-ferrous metals and alloys, &c. From information we have received it is apparent that, in addition to a fair number of new engines and recently developed plant to be shown, visitors will also be able to note interesting improvements in the design of equipment exhibited before. A large proportion of the exhibits will be shown in operation and numerous interesting demonstrations have been planned, particularly in the welding and foundry sections of the exhibition. As in former years, the stands and exhibits are being carefully arranged and well spaced to enable visitors to inspect in comfort the equipment shown. An exhibition such as this emphasises the importance of the engineering industry to the export trade of this country and shows the high quality and wide range of equipment being produced. In addition to the buyers from all parts of the world who will be visiting the exhibition, the organisers, F. W. Bridges and Sons, Ltd., have invited the members of no less than seventy trade and technical associations to attend. As in previous years, The Engineer stand will be situated near the centre of the Grand Hall and will be at the service of its many friends in the engineering industry.

Structural Light-Alloy Riveting with the High-Tensile Alloys

By J. G. WHITMAN, M.Eng., Ph.D., A.M.I.C.E.

IN recent years much time and thought have been devoted to the development of riveting techniques for the light alloys, and the need for such development has been intensified by the rapidly extending use of these alloys for structural purposes.

Up to a few years ago experience with the light alloys had been largely confined to the aircraft industry, so that the rivets, which were then available in diameters up to about ½in and made from special soft "riveting" alloys, were quite inadequate for the transfer of the higher shear intensities of structural joints. As a result there was an immediate demand for larger rivets and some methods have since been devised for producing rivets up to ¾in diameter in these same alloys.

This article describes a different approach to this problem in the development of rivets formed from the high-tensile alloys, so that the strength of the rivets are increased, not only by being made larger, but also by making the best use of the materials which are available. The author believes that this is a more logical approach to the problem and that the rivets so developed should prove considerably more economical in use.

Methods of Closing

In such development the first consideration must be the method of closing to be used and there is little doubt that cold squeezing and reaction riveting are the most practical for structural work.

Hot riveting with the alloys is very little

FIG. 1—CONICAL DRIVEN HEAD OF ½IN DIAMETER A.W.13 RIVET

practised because only a narrow range of temperature is available for riveting and very close control is required, particularly as there is no colour guide to the temperature as for steel and the rivet is rapidly cooled on coming into contact with the main material.

Hot steel riveting can and has been successfully used for light alloy structures. The heat from the rivets can be shown to have little effect on the heat-treated properties of the surrounding alloy, and this is probably because of the high specific heat and thermal conductivity of the alloys, which are between three and four times that of steel. There are, however, two strong objections to this practice. In the first place, the presence of steel in a light alloy structure rather nullifies the better corrosion resistance of the main material; and secondly, although this is not generally realised, steel rivets can add over 12 per cent to the total weight of the structure. Corrosion resistance and lightness moreover, are the two main reasons for using light alloys in structures.

There are many special kinds of riveting methods on the market which are very

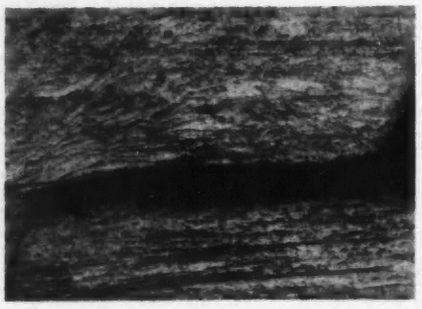


FIG. 2—PORTION OF FIG. 1 ENLARGED

useful for their own particular applications, but none of these can compete economically with the simple squeeze or reaction processes for normal structural work, and the object of this article is to show how these processes can be applied to the high-tensile alloys.

In point of fact, most of the work described has so far been concentrated on the squeeze process, but enough has been done to show that the same conclusions and processes will apply to reaction riveting.

Cold Riveting

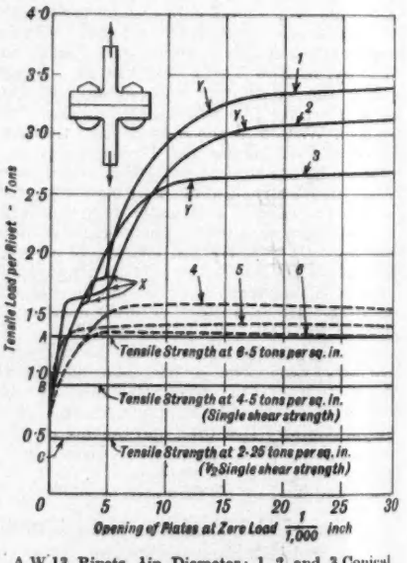
For an unbiased study of this problem it is most important to appreciate that a cold-squeezed rivet is fundamentally different to a hot-driven rivet. The material of the hot-driven rivet contracts on cooling and in so doing pulls the plates tightly together. It also shrinks a little in the hole, so that in operation shearing loads are partially transmitted through the frictional resistance of the surrounding plate; it is, in fact, a tension rivet and this probably accounts for the working of such rivets that sometimes takes place under reversed loadings. In cold riveting the exact reverse occurs. Under the closing pressure the rivet shank is subjected to a very high stress, so that there is a considerable expanding force tending to enlarge the hole. On release of this closing pressure there is some elastic recovery of the rivet shank and surrounding plate, which often is sufficient to raise the head or point clear of the plate by a small amount. Figs. 1 and 2 show a typical case of this sort. This is a enlarged view of a ½in diameter A.W.13 rivet squeezed with a closing load of 22 tons to form a normal type of conical point. It can be seen that the point has been in contact with the plate by the duplicated edge pattern and it is now raised clear by approximately 0·007in. In this process, then, the plates are not held tightly together, but the hole is very tightly filled so that in use the designer's assumptions on shear and bearing stresses are correctly fulfilled and the "frictional grip" of the hot-driven rivet is absent.

The hot-driven steel rivet has been established for so long that there is a very strong tendency to expect the same type of head and point from a cold-driven light alloy rivet; but, apart from tradition or perhaps prejudice, there is no reason at all why this should be so. The two kinds of rivet differ in their function under load in the closing method used and in material. They have therefore no points in common other than that they make joints and the same can be said for bolts and weld metal.

If it is agreed that there is no logical reason to copy a steel rivet, one is faced with the problem of designing a new head and point for the light alloy rivet, and for this some knowledge is required of their function. What, in fact, does the head or point of a cold driven light alloy rivet do? Obviously, they take no part in transmitting shearing forces as the condition shown in Figs. 1 and 2 is very common and tests show no loss of strength due to this cause. Their only possible function, therefore, is to take tension loads. Tension loads, however, are not recommended for these rivets and it is general practice in design to avoid such.

In order to establish the effect of tension on these rivets, tests were carried out as illustrated diagrammatically in Fig. 3. Extruded T sections in A.W.15B were used and cut into lengths sufficient to prevent undue bending of the flanges under the tensile loads of the rivets. Opening of the flange plates was measured by micrometer readings taken round the rivets. Six curves are shown and they are typical of results obtained.

Curves 1, 2 and 3 show the results of tests on six A.W.13 ½in diameter rivets with conical



A.W.13 Rivets, ½in Diameter; 1, 2 and 3 Conical Point; 4, 5 and 6 Headless.

FIG. 3—TENSILE TESTS ON RIVETS

points and snap heads cold formed with a closing load of 22 tons. On each curve, *X* shows where the clearance under the head or point has been taken up so that up to this the head and point have done no work and tensile loads have been transmitted by the frictional grip of the rivet in its hole. Curves 4, 5 and 6 represent tests of rivets of the same material and closed with the same pressure, but having no heads or points, and they behave substantially in the same manner up to tensile loads near to the points *X* and then

proceed to draw out of their holes at a constant load.

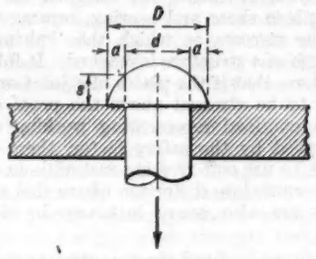
The point *Y* on curves 1, 2 and 3 is of interest as it indicates the stage at which the extension of the rivet has been sufficient to cause it to go slack in the hole. The conical points and snap heads are designed to develop the full strength in tension of the shank of the rivet and, with a working stress of 6·5 tons per square inch, this would give the working tensile load of *A* as shown on Fig. 3. It is important to note that these rivets could have withstood this tension without their heads and points and that overloads within the factor of safety would bring them into play, but only at the expense of developing a small opening between the flange plates.

These tests fully confirm the practice in design of severely restricting tension loads on this type of rivet. Some authorities recommend bolts for all such cases while others suggest a maximum tensile load of half the maximum shear strength. This value is represented by *C* on Fig. 3, and while it can be seen to be a safe and reasonable limit, it can also be seen to be a load that can be carried without rivet heads or points including a factor of safety greater than 2.

These facts have opened up the very attractive, if revolutionary, idea of headless riveting. Such rivets are made simply by cutting the extruded bar to lengths a little longer than the grip length and are formed by squeezing them between two flat riveting tools with a pressure exceeding 75 tons per square inch on the rivet area. This rivet should be long enough to finish slightly proud on one side of the plates and the other side may finish flush.

The attractions of such a riveting method are many. There is no restriction on the choice of alloy and very little on the clearance in the hole to be filled. Extruded bar is considerably cheaper than rivets, which usually must be cut to length anyway, simple forming tools are required and the rivets finish flush with the surrounding plate.

The successful functioning of these rivets depends on the frictional resistance of the rivet in its hole being sufficient to withstand such tension loads as may arise, and the author has work in hand to determine these values under varying conditions and when combined with shear. Much work remains to be done before such rivets can be generally recommended, but it is already apparent that there are many applications where they could be used with safety, economy and improved appearance.



When $D=1{\cdot}25d$ and $a=0{\cdot}25d$ the tensile strength of the head=shear strength of rivet.

FIG. 4—PROPORTIONS OF RIVET POINT FOR TENSION

Returning to the question of the function of the cold driven rivet head and point, enough has been said to show that their only purpose can be that of safeguard against occasional tension loads.

It has been shown that snap and conical heads and points can develop tensile strength in excess of that required from considerations of safety and in excess of that used in common structural practice. Such heads and points can obviously be reduced in size without detriment to the structure. If, therefore, a smaller head and point are designed to carry tension loads equal in value to the single shear strength, *B* on Fig. 3, this would give ample precaution against such tension loads which could be allowed.

Such an assumption gives a basis for design and making a further general assumption that the bearing stress on the ring of thickness *a*, Fig. 4, is 4/3, the tension stress and shear stress on the depth *S* is 2/3 the tension stress, one can arrive at minimum requirements for *S* and *D* to give this tensile strength.

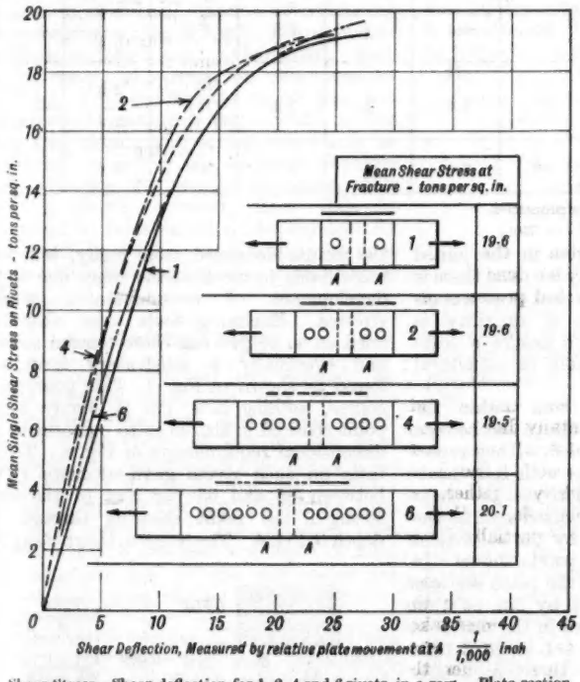
These are: $S=0{\cdot}25\ d$ and $D=1{\cdot}25\ d$ (allowing $0{\cdot}025\ d$ for clearance of the rivet in the hole).

These figures give heads or points very much smaller than the snap head, but they have been shown to be quite adequate for their purpose and being comparatively small can be formed with the high-tensile alloys.

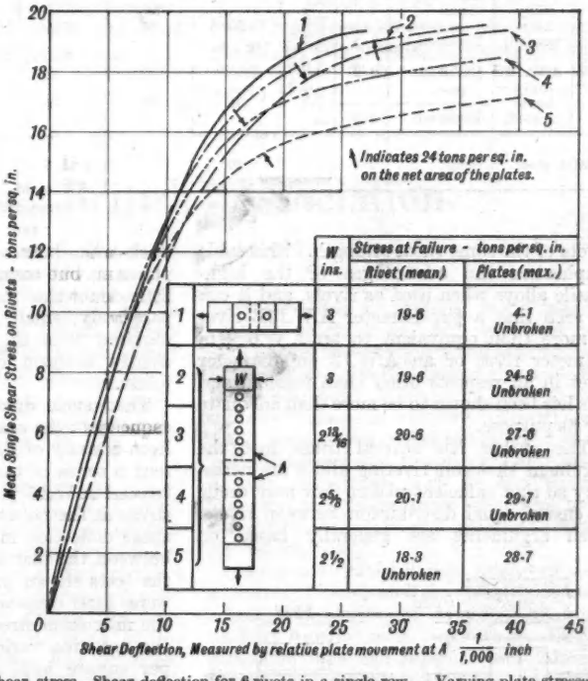
Rivet Material

A number of alloys have been recommended for riveting purposes, but they have been chosen primarily for their cold-forming properties, and for this reduced size of point it is not necessary to consider rivets from this angle. Indeed, recent work has shown that the tensile properties are no guide to the compression properties of these alloys and that most of them will cold form in compression as readily in the fully heat-treated condition as in the solution-treated condition. The softer alloys, moreover, are uneconomical riveting materials because, as they have work hardening characteristics, energy is expended in forming and work hardening the point, which does no work, while the rivet shank is left very much in its original soft state to carry the shearing and bearing stresses. The more economical riveting alloys are obviously those which have the lower ratios of closing load to shear stress, and they can be found in the fully heat-treated alloys, such as A.W.10B and A.W.15B. Apart from these considerations, however, the designer requires the strongest alloys in shear and bearing so that his rivets can be as small as possible for the shear force to be transmitted. Such rivets would give the best possible economy in that there is the minimum of loss of rivet hole area to tension members, and also in erection it is an obvious advantage to keep the drill sizes small and, if possible, within the limits of hand drilling.

It may, of course, be necessary to use the same alloy for rivets as for the plate because of severe corrosion conditions, and it may


Mean Single Shear Stress on Rivets - tons per sq. in.
Mean Shear Stress at Fracture - tons per sq. in.
19·6
19·6
19·5
20·1
Shear Deflection, Measured by relative plate movement at A 1/1,000 inch

Shear Stress—Shear deflection for 1, 2, 4 and 6 rivets in a row. Plate section constant. A.W.15B Rivets in double shear; ½ in diameter at 1½ in centres; A.W.15B plates 3 in × ¾ in.


Mean Single Shear Stress on Rivets - tons per sq. in.
Indicates 24 tons per sq. in. on the net area of the plates.
W ins. | Stress at Failure - tons per sq. in. | Rivet (mean) | Plates (max.)
3 | 19·6 | 4-1 Unbroken
3 | 19·6 | 24·8 Unbroken
2 13/16 | 20·6 | 27·6 Unbroken
2 5/8 | 20·1 | 29·7 Unbroken
2 1/2 | 18·3 Unbroken | 28·7
Shear Deflection, Measured by relative plate movement at A 1/1,000 inch

Shear stress—Shear deflection for 6 rivets in a single row. Varying plate stresses. A.W.15B rivets in double shear; ½ in diameter at 1½ in centres. A.W.15B plates ¾ in thick; Cover plates ¾ in thick.

FIGS. 5 AND 6—RIVET SHEAR DISTRIBUTION TESTS

also be advisable to use the soft riveting alloys for ease of riveting where the pitch of rivets is decided by other considerations than shear stress to be transmitted, e.g., watertight joints. Apart from such considerations, however, the designer's choice of material for stressed rivets can soon be made from a study of the shear and bearing properties of the alloys. In the table these properties of two standard riveting alloys, A.W.6 and A.W.13, are compared with the two common structural alloys, A.W.10 and A.W.15, in the fully heat-treated condition and mild steel has been added for further comparison. It can be seen how A.W.15 rivets are twice as strong in shear as A.W.13 rivets, and as bearing is not often a criterion in structural design, the last part of the table has been included to show the relative values of rivets of the same shear strength. This table emphasises the advantages of the high-tensile alloys when used as rivets, and it can be seen that a $\frac{1}{2}$in diameter A.W.15B rivet is more than equivalent to an A.W.6 $\frac{13}{16}$in diameter rivet or an A.W.13 $\frac{7}{8}$in diameter rivet in all respects other than tension, and this has been shown to be more than adequate for its purpose.

Table of Properties and Comparison of Riveting Materials and Rivet Points

Riveting Alloy		Rivet Point: Type	Rivet Point: Working tensile strength, tons per square inch on shank area		Bearing strength, tons per square inch: Yield	Bearing strength, tons per square inch: Ultimate	Bearing strength, tons per square inch: Working stress factor of 1·6 on yield	Single shear strength, tons per square inch: Yield	Single shear strength, tons per square inch: Ultimate	Single shear strength, tons per square inch: Working stress factor of 1·6 on yield	Rivets of approximately same strength in shear: Diameter (inches)	Working strength in single shear (tons)	Working strength in bearing on ½in plate (tons)	Working tensile strength (tons)	Squeeze load to close (cold) (tons)
Present-day normal practice	A.W.6 (soft)	Snap	5·0	Factor of safety 1·6 on tensile proof stress	17*	31*	10·5	6·5*	11·5	4·0	$\frac{11}{16}$	2·8	4·9	3·5	120*
		Conical	5·0											3·5	75*
	A.W.13 (solution treated)	Snap	6·5		19	34	11·5	7·5*	12·5	4·5	$\frac{7}{8}$	2·7	5·0	3·9	110
		Conical	6·5											3·9	65
Recommended practice	A.W.10 (fully heat-treated)	Reduced pan	6·5	Point designed to develop shear strength	20	36	12·5	11*	14	6·5	$\frac{3}{4}$	2·9	4·7	2·9	35
		Recessed	6·5											2·9	25
	A.W.15 (fully heat-treated)	Reduced pan	9·0		34	60	21·0	15	19	9·0	$\frac{5}{8}$	2·8	6·6	2·8	30
		Recessed	9·0											2·8	21
Mild steel		Snap	9·0		20	—	12·5	10	20	6·0	$\frac{3}{4}$	2·7	4·7	4·0	—

* Estimated from other properties.

The author has several times met the argument that soft riveting alloys are necessary so that sufficient plastic flow may occur to ensure equal distribution between rivets. Such arguments are generally based on reports of tests to failure of riveted joints in which a comparatively ductile parent metal reaches the plastic state before failure occurs. Under such conditions the failing strength per rivet can be shown to fall as the number of rivets in the joint increases. In practice, however, a joint would never fail in this way as the structure of which it forms a part would have failed by the collapse of some compression member, or by excessive distortion, at stresses at the commencement of the plastic range, long before these ultimate stresses were reached. It is for this reason that structures are designed on the proof stress of the material and for the same reason rivets are, or should be, designed on yield strength in shear and bearing, because these are the stresses at which the "ultimate" strength of a structure is reached. It follows, therefore, that if the plates of a joint are not going to be stressed above the proof stress at an overload representing working stress multiplied by the safety factor, there is no reason to use soft riveting materials in order to accommodate distortion above this stress. There are also many instances in riveted work where the actual stress in the joined plates may be comparatively low, and there is little doubt that for all practical cases a comparatively small amount of ductility is required from the rivets to ensure a sufficiently uniform distribution in structural joints.

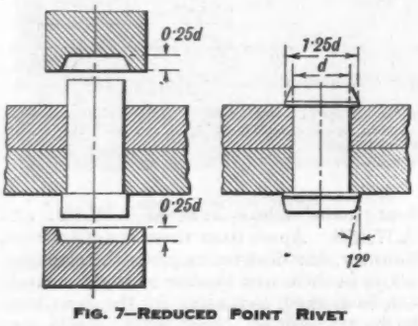


FIG. 7—REDUCED POINT RIVET

That such ductility is well within the capacity of the aluminium alloys can be seen from a study of Figs. 5 and 6. They represent a series of tensile tests with fully heat-treated A.W.15 plates and rivets, the shear stress in the rivets being plotted against the shear deflection measured by the movement between the plates at the points shown. In the tests shown in Fig. 5 the plate sections were kept constant at $\frac{1}{2}$in by 3in, so that the maximum stress reached in the plates on the net area varied from 4·1 to 25·2 tons per square inch and are therefore mostly within the proof stress of the alloy. It can be seen that the distribution between rivets has made no measurable difference to the behaviour under load of one, two, four or six rivets in a single row. The tests also show that 15 tons per square inch is a fair assumption for the yield stress in shear of A.W.15B. Fig. 6 shows the results of tests on six rivets in a row with the plate stresses varied by reducing the cross-sectional area. It can be seen that when the stress in the plates is high enough to cause plastic flow, unequal distribution on the rivets becomes apparent, but in all cases the shear ductility of the rivets is still adequate to prevent reduction of the ultimate value when using the A.W.15B alloy. It is evident from these tests that distribution can be safely assumed to be 100 per cent for this type of structural joint.

REDUCED PAN RIVET

The object of the development was in this way narrowed down to the problem of cold forming a point on a fully heat-treated A.W.15 rivet with an overall diameter of 1·25 *d* and a depth *S* of 0·25 *d*, as shown in Fig. 4. This would give a point which would develop a tension load approximately equal to the single shear strength of the rivet and being formable with the hardest of the structural alloys could then, if so required, be applied to any of the other alloys.

Many shapes of forming tools were tried, including all angles of conical types. From these it was found that with flatter angles the points deformed more easily, but were more liable to crack at the edges due to the development of circumferential tension stresses. Enclosing tools were, therefore, tried so as to prevent these tension stresses and eventually a satisfactory form was found as shown in Fig. 7. This point is, of course, nothing new, but is simply a pan point reduced in size so as to conform to the dimensional requirements of Fig. 4. Tensile tests on such rivets gave ultimate values between 85 and 95 per cent of the shear strength, the point shearing through the depth *S*, Fig. 4. The recess in the riveting tool was, therefore, increased to 0·25 *d*, so that in practice the rivet point finished slightly deeper than this and was able to develop 100 per cent of the shear strength. The fully heat-treated A.W.15, which deforms a surprising amount if not allowed to develop tension stresses, forms readily to

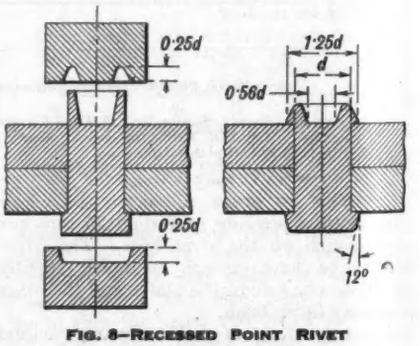


FIG. 8—RECESSED POINT RIVET

this shape under a closing pressure of approximately 100 tons per square inch on the shank area, e.g., 20 tons on a ¼in diameter rivet and 30 tons on a ⅜in diameter rivet. Similar rivets in fully heat-treated A.W.10 alloy require a closing pressure of 80 tons per square inch on the shank area.

During this investigation some trouble was experienced with the tilting of rivets during the closing operation. This effect was, of course, exaggerated by the comparatively small size of the "job" in the case of riveting specimens, but such action is clearly undesirable and in practice liable to twist the riveting yoke and form bad points.

The control of this action lies in the design of the head. Various forms of head were tried, and of these the flat head was found to give the least severe tilting. The flat head, however, spread alarmingly under load, and after some experiment the head shown in Fig. 7 was evolved in which the spread of the flat head is restrained as in the pan point. The angle of 12 deg. shown is the minimum necessary to prevent the lower tool binding and the head in Fig. 7 forms to this shape in the riveting process. This type of head offers attractive possibilities for workshop manufacture where comparatively small numbers are involved because the rivet now developed is the simplest possible shape and with automatic lathes could be machined from the extruded bar quickly and cheaply. Many structural workshops are so equipped and with the rivet lengths determined accurately from the job the most difficult business of estimating rivet lengths or the wasteful alternative of cropping to length can be eliminated. Such saving must, of course, be offset against the cost of machining and metal lost, but the amount machined away could be less than that shown and, in fact, need only be sufficient to provide an adequate shoulder for positioning the rivet in the plates. The 12 deg. angle, however, must then be increased to form an adequate shoulder for the head, and this could only be done with some lowering of the resistance to tilting.

Recessed Rivet

The closing loads for the reduced pan rivets compare favourably with the loads required to form snap and conical points in the softer alloys, as can be seen from the table, but, nevertheless, the closing loads are high and for rivets over ¼in diameter are often outside the capacity of the tools held by workshops. The recessed rivet shown in Fig. 8 has been developed to meet this situation, and its use will enable the closing load to be reduced by approximately 30 per cent.

The rivet is similar to the reduced pan rivet except that the end is counterbored, as shown in Fig. 8, to approximately the level of the surrounding plate. This end boring entails extra work in manufacture, but the whole is still a simple machining operation for an automatic lathe and, therefore, producible in large numbers and at comparatively reasonable cost.

The object of this counterbore is simply to reduce the area of metal under compression and so increase the stress without increasing the load. In the riveting operation the cylindrical wall of the head is upset by the pressure and conforms to the shape of the closing tool. The inner diameter of the recess has been decided by the same considerations as for the design of the reduced pan point and assuming the tension stress is 3/2 times the shear stress, this internal diameter must be $0{\cdot}56\ d$ to satisfy the condition that the point should carry in tension a load equal to the single shear strength.

In fully heat-treated A.W.15 this rivet requires a closing pressure of approximately 70 tons per square inch on the shank area, and the value of such development can be appreciated by the fact that a squeeze load of 21 tons, which is required to close an A.W.13 ¼in diameter rivet with conical point, will also close an A.W.15B recessed ¼in diameter rivet which is worth three times the value of the A.W.13 rivet in shear strength.

It has been found that 70 tons per square inch is the minimum stress necessary to fill the hole tightly with A.W.15 alloy, and there is consequently no advantage in experimenting with smaller points to develop, say, 75 per cent. of the shear strength because no further reduction of closing load is advisable.

This point is not formed by enlarging the rim through a wedging action from the central spigot as this would lead to the development of tension stresses and hence cracking. This central spigot only serves to restrain the inward flow of the material during the upsetting action. The principle of forming these rivets is also quite different from that of the "annular" rivet used in the construction of the Arvida bridge, which was described in an article published in *Engineering* on August 11, 1950. The recess in the centre of this "annular" rivet is too small to reduce the area effectively and serves mainly as a location for the central point of the riveting tool for the rotating action of the hammer. It is extremely doubtful if such a point could be formed with the high-strength alloys.

Reaction riveting has been successfully carried out on both the types of point described in this article and the fully heat-treated A.W.15 alloy deforms quite readily, although heavier hammers are required than for the softer alloys of the same diameter. In this riveting, both of these new points have an advantage over the snap or conical point, in that there is less metal to upset and also that the rivet shank locates snugly into the bottom of the riveting tool and so holds the hammer central on the rivet.

A heavy slow-hitting hammer is required for this work with all types of point for two reasons. First, a light fast hammer tends to harden the extreme end of the rivet without swelling the shank, and secondly, there is a tendency to thrust the head away from the plate unless there is time for the holding-up dolly to recover after each blow. The weight of the holding-up dolly is exceedingly important and generally should be as heavy as circumstances will allow.

In this article the author has tried to describe the development work that is being carried out in light alloy riveting at the Military Engineering Experimental Establishment and the fundamental reasons for what appears to be a new approach to the problem. There is a great deal of work yet to be carried out, but the types of rivet so far developed are being used and while proving no more difficult than the standard types, they are effecting considerable economies in numbers of rivets and sizes of members.

The author is indebted to the Chief Scientist, Ministry of Supply, for permission to publish this article and to his colleagues at the Military Engineering Experimental Establishment for their interest in the work.

The British Association

No. II—(*Continued from page 208, August 17th*)

WE continue below our account of the annual meeting of the British Association for the Advancement of Science, which was held in Edinburgh from August 8th to 15th.

The Changing Face of the Chemical Industry

In Section B, Chemistry, on Friday morning, August 10th, Mr. H. W. Cremer, President of the Royal Institute of Chemistry, spoke on "The Changing Face of the Chemical Industry." After a brief reference to the effects produced by the rapid growth of the chemical industry during the nineteenth century, he indicated some of the factors which, in his opinion, had influenced its development in more recent years. In particular, he stressed some of the undesirable features of the industry in its earlier history, such as atmospheric and water pollution, and he attributed a considerable measure of responsibility for this to a general public which permitted these happenings without active protest.

Among the factors which Mr. Cremer cited as giving rise to a different outlook and better conditions within and without the industry were the following :—

First, the increasing competition from the increasing number of industrially minded countries abroad, necessitating higher process efficiencies and consequently less waste of materials to the atmosphere or to streams and rivers. Secondly, the extension of the industry to include a much wider range of products, such as textiles, foods, pharmaceutical preparations, &c., which of their very nature necessitated manufacturing techniques of an entirely different character from those employed hitherto in the so-called "heavy" chemical industry. Nowadays, he said, agricultural requirements as regards both fertilisers and insecticides also formed a very important part of the chemical industry, and the prospect opened up by the utilisation of synthetic plastics appeared almost limitless.

As regards the appliances employed in this extremely varied and far-reaching industry, scientific discovery—if it was to be applied usefully—made more and more exacting demands upon the designer and fabricator of chemical equipment. Many present-day processes operated upon an immense scale, required pressures undreamed of on an industrial scale even a few decades ago, and sometimes those high pressures had to be combined with comparatively high temperatures. Not only had the chemical engineer made many contributions in this field in extending knowledge of the principles on which plant design was based, but his work would be largely unavailing had not the metallurgist produced the special constructional materials needed to implement those designs.

One outstanding contribution which the chemical engineer had made was to view in selected categories, instead of piecemeal, the process operations used in the very extensive range of industries with which he was con-

cerned. He had recognised that the physical principles underlying those operations were the same, however different in form the appropriate appliance might be for a particular product. This apparently obvious concept had quite revolutionised the teaching and profession of chemical engineering, and the chemical industry had greatly benefited accordingly. To-day the chemical engineer recognised a number of "unit operations," such as size reduction, size separation, evaporation, drying, distillation, filtration, and so on. The principles underlying them were common to all industries, although the actual method of applying those principles might differ with the properties of the individual product to be manufactured. Mankind could not reap the benefit of the genius of the research chemist unless the chemical engineer was able to translate the work of the laboratory to the factory scale, and in this respect immense strides had been and were still being made.

Lastly, Mr. Cremer referred to the safety and welfare of the workers employed in the chemical industry and to some of the hazards which they encountered. He said that the study of occupational diseases had advanced greatly in recent years, and this was one of the factors which had clearly created in his mind the picture of an industry that was somewhat haphazard and irresponsible at the outset, but was now integrated and much more conscious of its obligations to the public.

Section G, Engineering

In one of the two sessions into which Section G, Engineering, divided on Monday morning, August 13th, papers were presented by Mr. C. E. Iliffe on "Recent Developments in the Methods of Proportioning Contra-flow Heat Exchange Apparatus," and by Mr. A. Hampson on "Heat Transfer During Condensation of Steam." In the other session, the first paper discussed was by Mr. T. Graeme N. Haldane, M.I.C.E., M.I.E.E., on "The Development of High-Voltage Transmission with Particular Reference to Hydro-Electric Projects." This paper traced the development of high-voltage power transmission up to 400,000V and dealt with some of the more important problems of extra high-voltage transmission. Reference was made to the new 275,000V British grid system and to the possibility of connection with the Continent by submarine cables.

Concluding his paper, Mr. Haldane said that with each upward step of transmission voltage, new technical problems were presented, the overcoming of which not only required time and experience, but also insolved heavy cost. It must not therefore be, too readily assumed that any voltage level, however high, was merely a matter of time. It might be some considerable time before 400,000V was exceeded; nevertheless we were probably within sight of the half million volt mark, enabling blocks of a quarter of a million kilowatts to be transmitted per circuit over distances not far short of 1000 miles, though whether such transmission would be economic was another question. Direct-current transmission might eventually supersede alternating current and increase this limit, but it would appear more probable that, for economic reasons, direct current would be used initially for the submarine cable transmission of very large blocks of power.

Sir Harold Hartley, opening the discussion, said that he had a very strong feeling about the importance of the question of the transmission of large blocks of power in the future. As he hoped he had made clear in his address the previous year, in looking at the world picture the future depended more on supplies of energy than on any other single factor. At the present evaluation, the potential water power in the world was just equivalent to the total energy consumption of the world to-day, but only a small proportion of that water power was actually being tapped. The rising fuel costs and the fact that a major, limited capital resource was being used gave immense importance to the full utilisation of hydro-electric power in the future.

As the author had said, a large proportion of that hydro-electric power was placed at very great distances from what seemed to be the likely centres of consumption. Although in this country the prospect of d.c. transmission might be a very small one, he thought that, looking to its probable importance in the world as a whole and looking to the future of the export market, it was a problem which merited the fullest discussion and development in this country, in order that we might be able to evaluate as closely as possible what were going to be the economics of the future.

Sir Claude Gibb said that his studies had led him to believe that a consumption per head of the population of Great Britain of five times the present consumption would not produce demand saturation. It was, he felt, absolutely certain that the fact that we were short of energy, whether coal, coke, gas, electricity or petroleum, was the surest indication of the increase in the standards of living compared with pre-war days. The one thing that had not kept pace with improvements in the application of electricity and power generally in the service of man, increases in productivity, and improvements in the standard of living, was the output of fuel. He saw a very gloomy future at any rate over the next ten years. There was no question that it was absolutely essential that every possible source of alternative power should be brought in to help in the fuel shortage, and inevitably the bringing in of those alternative sources of power would involve the use of long-distance extra high-voltage transmission.

Professor R. O. Kapp commented on the limitations of long-distance transmission. Those who had grown up with lower voltages tended to believe that in order to increase the distance one increased the voltage, and that the two things went together. But the fact was that, with alternating current, when approaching the border line—which at 50 cycles was 930 miles—there was another set of difficulties. Greater distances could not be overcome merely by increasing the voltage or by any changes in the line construction. The two factors that imposed limits at long distances were what was known as the Ferranti effect—the rise of voltage on switching off—and the phase displacement between the ends of the lines, of which the theoretical limit was 90 deg. Both of those could be shown to be a function of distance, a function of the frequency and a function of the velocity of light—over which they had no control! If, in addition to increasing the voltage, it was wanted to increase distances above 400 miles, there was nothing to do but have frills, such as shunt reactors and series capacitors.

Mr. F. C. Winfield said that the general problem in relation to water power was that the water was in the mountains and the population was on the plains. The nearby "plums" had been gathered, and it was now necessary to go some distance to get the power. Year by year the power was getting farther away, and it was an ordinary economic factor that as it got farther away it must be dealt with in larger blocks in order that the economics might be kept right. The cost of transmission was a major issue in any development of water power. In alternating current it was necessary to keep down the unit cost and, to stretch the transmission distance, the voltage had been pushed up slowly over the last sixty years until at present it had reached nearly 400kV. With these higher voltages the cost of terminal plant was rising and the cost per unit of the total plant was getting very heavy. The lines had been stretched further. In effect, there had been a reduction in capacity. The cost per unit went up, not only because of distance, but because the capacity was coming down. By introducing twin conductors it was possible to compensate for distance, and so forth, but these were costly expedients to keep the plant capacity up. The position had been reached when the prospect ahead was larger and larger schemes at greater and greater distances, with the cost of transmission per unit tending to rise all the time. He could not see any particular way in which the cost could be held down. That led to the consideration of direct current. The particular property of direct current was that it could not be considered for small powers because of the heavy cost of terminal equipment, and it must therefore be considered for large powers. Over small distances direct current could not compete with alternating current, but for long distances direct current offered an inherently cheaper line without many of the disadvantages of alternating current. Therefore, in the future, with larger powers over larger distances, it appeared that direct current could come in and compete effectively with alternating current, thus helping to keep down the costs of transmission and the development of water power.

Mr. Winfield went on to say that he could see many possibilities with the underground cable. The author had mentioned a few, such as the cross-channel cable. Only during the last few weeks he had himself had an inquiry on this matter from Canada. In Eastern Canada the position was that they had worked out the "plums" so well that there were none left. In Eastern Canada the water power had all been put into use, they had no coal handy and it was very expensive to import it. They were now in a very difficult position, and were now considering the Hudson Bay coal—but that was many miles away. It had recently been pointed out that they could shorten the distance quite a lot by cutting across the floor of the bay, and they were asking whether they could have a direct-current cable. Again, as was pointed out in the paper, the saturation of the steam stations in the Thames estuary meant that economic considerations were compelling those concerned to contemplate using Midland coal in London. London was the only natural centre of population in the country that was not built on a coalfield, and all the power had to be sent into London. It was sent in by ship to the estuary stations, but it was not possible to get any more such stations. It was necessary to go to the Midlands for coal, but there was alternative of bringing in something like one million kilowatts to London over wires. That would see the situation through to 1960. But in 1970 five million kilowatts would be needed. Many people had considerable objections to overhead lines. Personally, he did not find a single line ugly, but when there were two lines together he did not like them—there was no longer any rhythm about them. If in twenty years' time there were an attempt to send five or six million kilowatts from the centre of England to London, he feared that there would be a terrible public outcry. The

alternative was direct current. He therefore maintained that there was a clear case for continuing the investigation of direct current. It was a question now of "Give us the money and we will do the job."

Mr. T. Lawrie felt sure that everybody would share the author's doubt about the prospect of this country getting enough coal in the future, but he emphasised again, as Sir Claude Gibb had done in his presidential address, that one of the obvious ways of saving coal was to have more and more electrification. If there could be double the amount of electrification and at the same time an increase in the thermal efficiency of power stations from 20 per cent to 25 per cent, in round figures, the result would be double the amount of power for very much less than double the amount of coal. If that doubled amount of power were to be put to good use, it would be used in factories as a more efficient form of motive power than the present form, and there again there would be a saving, because far fewer factory chimneys would be belching black smoke as a result of incomplete and inefficient combustion. If the railways were electrified, he believed that there might be a saving of nine million tons of coal. He had been told that even if the coal mines themselves were electrified there would be a saving of something like six million tons. Those were very substantial items, not perhaps in the coal budget of the country as a whole, but at any rate in the coal budget of the electricity industry. If the supply industry in the next few years could show savings of that magnitude in coal consumption, then there should be no apprehension at all in looking forward to the more rapid construction of the power stations which were so greatly needed.

Dr. A. P. Thurston, commenting on the subject of overhead lines, said, as one who had been a flying man for many years, that he did not like the lines being put in positions where aircraft could fly into them. He liked the lines to be kept in the valleys so that aircraft did not fly into them when cutting over the tops of the hills.

Mr. A. Feiner felt that it ought to be considered very seriously, in conjunction with direct-current transmission and the higher voltage transmission of alternating currents, that there was a growing probability that, instead of having to take the power to the people, the people would have to be taken to the power. He thought that this was already happening to a great extent, and it was becoming more and more necessary as towns were increasing in size. With regard to line charging capacities, particularly in conjunction with very high-voltage alternating-current lines, one of the difficulties of the water turbine generator designer was the provision of stable line charging currents. He would like to have some information on what was the line charging capacity per mile of a 275kV or a 375kV single-circuit system as compared with a 132kV.

Mr. Colin Cherry said that one thing which the author had not mentioned was the possible influence which modern research on high dielectric constants and the materials of high dielectric constants might have on transmission in the future. Might not this provide great assistance in the transmission of direct current, for instance, in the conversion from high to low voltage, and *vice versa*, and might not such materials affect the design of high-tension transmission lines?

Hydro-Electric Development in Scotland

Mr. T. Lawrie then presented his paper entitled "Electrical Aspects of Modern Hydro-Electric Development in Scotland." It surveyed the duties of the North of Scotland Hydro-Electric Board, under four headings, as follows:—(1) Responsibility for all future hydro-electric development in the Highlands and for the generation of electricity also by any other means which included steam turbines, gas turbines, diesel engines and wind power. (2) The priority duty of distributing electricity in the Board's area, which was that part of Scotland lying north of a line from the Firth of Tay to Loch Lomond and the Mull of Kintyre. (3) The export of surplus power to the British Electricity Authority in Central Scotland. (4) Collaboration in carrying out measures for the economic development and social improvement of the Board's area.

Sir Claude Gibb said that one thing that struck him in the paper was the conclusion that the only way to solve the electricity shortage was to build more power stations, and to build them fast. He did not think it was generally realised that one thing which was contributing in a major degree to load shedding of electricity in Great Britain was the rationing of coal and coke. If there were an adequate surplus of coal and coke for domestic uses, there would not be the installation of something like two million kilowatts of electric open-bar type radiators. Despite all the exhortations, appeals and broadcast warnings, if people were cold and they had a switch which they could knock down in order to warm themselves, they were certainly going to knock it down.

Mr. T. G. N. Haldane referred to the scale of developments in Scotland compared with what was required. He hoped that future developments would be undertaken at the lowest practicable loading factor and would make the biggest possible contribution to the peak demand. With regard to kilowatt-hours, he was afraid that the scale was not very hopeful. If he was right in thinking that, in the comparatively near future, they would be 10 million tons short, this would mean about 50,000 million units. Mr. Lawrie had pointed out that the maximum conceivable development in the coming ten years would be about 10,000 million units. This was probably a pretty optimistic figure, but it would only go halfway to meet the probable coal shortage. The figure of 10 million tons was admittedly only a guess, but he was certain that if it was wrong the error was in putting the figure too low rather than too high. Therefore, although the hydro-electric developments in Scotland would make a very important contribution, they would not get the country out of trouble so far as the coal shortage was concerned. In considering the economics of future hydro-electric developments in Scotland, he thought that in applying the thermal yardstick to which he had referred in his own paper it would be not unreasonable to assume the imported cost of coal rather than the cost of coal as produced in this country, because the alternative to not proceeding with further hydro-electric development in Scotland might very well be importing coal at a very much higher price than the present pithead prices in this country. He felt that it would be reasonable to use that yardstick in considering future development.

Mr. Haldane also expressed his interest in the author's reference to wind power. The most recent examination seemed to indicate quite clearly that the economics of wind power were going to improve pretty rapidly with the size. Very small windmills were very cheap; then the prices rose until the 100kW mark was reached—which was the size in the Orkneys—and then proceeded to fall steadily to much lower figures for wind generators of, say, 2000kW to 4000kW capacity. Although there were many difficulties to be overcome, he thought there was a very good chance of the economic development of wind power. If one took a rather rosy view and rather glossed over some of the technical problems to be solved, there was at least a hope that wind power development in Scotland might perhaps some day be almost as important as hydro development.

Mr. A. Feiner pointed out that the author had not explained that a large number of the high-voltage lines shown on the map in the paper had been constructed very recently within the lifetime of the North of Scotland Hydro-Electric Board. That was a tribute to the Board in hastening forward hydro-electric schemes which had lain dormant, for one reason or another, for at least half a century. There were two points on which he would like to have some information. The wind turbines in the U.S.A. was governor machines with variable pitch blades. What was the system in the Orkneys? The second point concerned rural electrification. It seemed that there were serious problems involved in rural electrification in Scotland, and he felt that in this respect it would not be out of place to say that surprisingly the highest rural electrification in the world appeared to be in Japan. There it was run on similar lines, i.e., hydro-electrification with high-density rural electrification.

Mr. Lawrie, in reply, said that the governor in the Orkney windmill was on the same lines as in the U.S.A. machine. Distribution in rural areas was a very big problem. At the beginning of distribution in rural areas, in most areas only one farm in fourteen had been connected to the mains. The Board had been struggling to make up the leeway. When one considered that in the U.S.A. 85 per cent of all farms were already on the mains and only 15 per cent had to be connected, that showed that there was quite a well-blazed trail which the Board had to pursue as rapidly as it could. The biggest problem was on the economic side; because of the scattered population, it was necessary to build two, three or four times as many yards of line to supply each consumer. That compelled the Board reluctantly to ask for guarantees or capital contributions, or both, from the consumers. This was not something which the consumers liked, and equally it was not a thing which the Board liked to have to do, but with materials at their present prices there was no option. It was only to be hoped that continuing rises in prices and scarcity of materials would not delay progress unduly, because, after all, food came first—even before shelter, perhaps—and it was from these areas that a great deal of the country's food came.

Section L, Education

In Section L, Education, on Monday afternoon, August 13th, Dr. P. F. R. Venables, Principal of the Royal Technical College, Salford, gave a paper on "Technical Education in the United States and Great Britain—Some Comparisons."

Dealing with the range of courses in the United States, he said that the emphasis on getting a job done on a deadline implied a great interest in the material or object produced, and so the term "engineering" included all those applications of science required for the manufacture of an end-product. The term "engineering" had a much wider application than in Great Britain and included various technologies. There was therefore in the United States a greater differentiation of courses for degrees in engineering, as might be gathered from the fact that there were courses in ceramic engi-

neering, chemical engineering, geological engineering, industrial engineering, petroleum engineering, textile engineering, and so forth.

The prestige and all-pervasiveness of engineering had led to such self-contradictory concepts as "human engineer," "social engineering," and the like. Courses in engineering and business administration had been described as courses in social technology. There was little doubt that these courses had been established, at least partly, to provide for students who could not meet the full demands of the technological courses, and they were in consequence regarded as an intellectual soft option. But there was even less doubt that the courses had justified themselves completely, both as regards the students, who were primarily interested in people and management and less in initiating and developing processes; and also as regards industry which, because of its increasing complexity and its social problems, needed such trained people. That was a very marked difference from the British system, and he felt that this country would do well to examine, not least in relation to productivity problems, whether there was not a serious gap here in the British system which was not met by the existing courses in production engineering.

The other major difference in the provision of courses was in chemical engineering. They had undergone an astonishing development in the United States in the last thirty years, and now closely followed in magnitude those in civil, electrical and mechanical engineering respectively. This development had taken place in both undergraduate and postgraduate schools, and it was important to note that the undergraduate courses were regarded as indispensable. The view was firmly held that without them it was not possible to supply all the chemical engineers required for the maintenance as well as the development of industry. This was in sharp contrast to the view which regarded the best and the only real method of training chemical engineers to be the provision of postgraduate courses for engineers and chemists entirely within universities or higher technical institutions. It was not without significance that it was in American chemical engineering education that one found a very special emphasis on works experience as an integral part of the training, and notably in the highly successful works practice schools.

It was important to notice that both these classes of training—engineering and business administration, and chemical engineering—had produced a stream of graduates who had risen to the highest posts in American industry. Such courses were very acceptable to industry and had in turn received increasing support from industry. But they were only part of a significant difference between the two countries, namely, the greater accessibility of the highest posts in industry and elsewhere to educated technologists. There was, moreover, a wider range of posts available, and there were good indications that something like two and a half times as many trained people at a degree or comparable level were being employed in the U.S.A. as in Great Britain.

In reply to a question during the discussion that followed, Dr. Venables said that it was these courses in engineering and business administration which had made the graduates acceptable in industry. They got into positions of power in industry and were readier to accept new ideas and more able accurately to judge the value of those ideas. That led to a readier acceptance of new ideas coming from the research workers. One of the contrasts between the two countries was that in administrative power in industry in Great Britain there was a far greater recruitment from non-scientific and non-technological people than from the technological side. The consequence was that in this country the responsible executives, coming from the commercial side, were more ready to see a new idea as an expense!

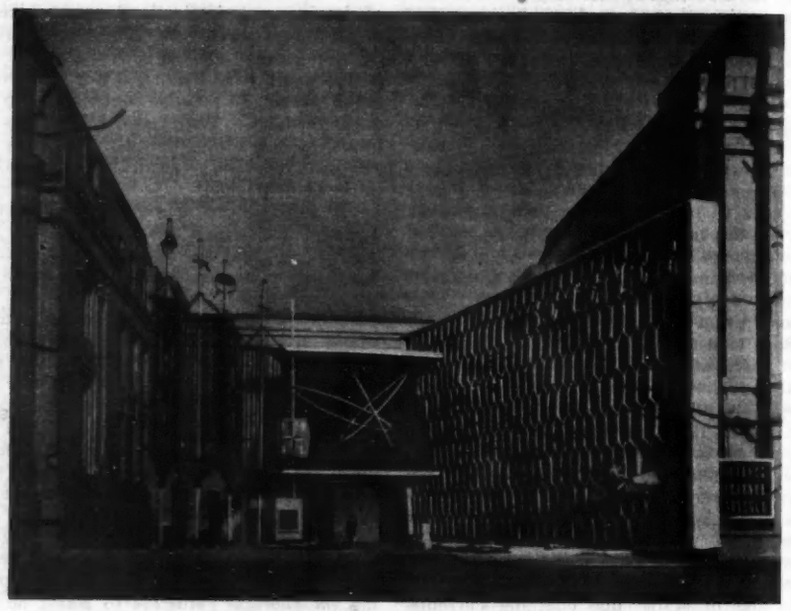
(To be continued)

The Exhibition of Science

A CONTRIBUTION of particular worth to the Festival of Britain activities is the Exhibition of Science, housed on the ground floor of the new west wing site of the Science Museum, South Kensington. Whereas the pavilions of the South Bank deal broadly with the more practical applications of science to civilisation, the exhibition at South Kensington aims to portray the manner and extent to which the structure of the material world has so far been resolved. It endeavours also without undue emphasis to indicate the sustained nature of British contribution towards this resolution since the sixteenth century. The exhibition develops as a narrative display and considers first the atom and then the cell, concluding with the most recent researches and findings of pure science. The success of this exhibition derives principally from its extensive use of laboratory apparatus and animated models, without which so vast a theme could hardly be compressed within a single exhibition or so compactly arranged. An original and impressive decorative motif has been chosen which is derived from crystal structure patterns. Much of the furniture, curtaining and wall decoration employs these patterns, and the illumination itself is obtained from lamps arranged in a frame as to represent the atoms in a long chain hydro-carbon molecule. With our description of the exhibition, which is mostly restricted to the section on physical and chemical structure, we show several interior views of the displays.

By way of introducing the dimensions of its subject, the entrance to the exhibition is through a series of chambers, in which a pencil line is progressively magnified. At a stage when magnified ten thousand times the graphite crystals surmount what appear to be mountainous peaks upon the paper surface, and with a final magnification of 10^{10} the carbon atom is revealed as having a "nucleus" or "sun" surrounded by "probability clouds" of electrons. With this impression of the atom the narrative continues along the main central corridor, which is dominated at its head with a giant mural of the Periodic Table. In this corridor there is first a quantitative display of the ninety-odd elements, showing the proportions in which they occur in the earth's crust. Each element is represented by a sphere; oxygen, which composes half the earth's crust by weight, is the largest and is about 5ft in diameter. Next is silicon, a quarter of the earth's crust, whilst the elements aluminium, iron, calcium, potassium, and sodium appear as substantial quantities in that order. The majority of the other elements to this scale are generally smaller than a tennis ball and most are of minute dimensions. The physical and chemical structure of compounds is portrayed, showing in particular the three ways in which atoms "bond" together. As well as the covalent bond and the ionic bond, it portrays the metallic bond, which is of particular interest to engineers, as it explains most of the properties of metals. The atoms separate into a regular pattern while their electrons are stowed throughout the metal, forming a cloud. This immediately explains why metals are good conductors of heat and electricity and why they emit electrons, as in a radio valve, when they are heated.

As "commonsense" evidence of the existence of molecules one sees a representation of the change of state and of an animated model of molecular activity as first observed by Robert Brown in 1827. There are other models representing electron shell structure,



EXHIBITION ENTRANCE

with examples of both active and stable shells, such as lithium and helium respectively. Another section deals with organic chemistry, i.e., the chemistry of carbon. Carbon has four electrons in its outer shell, which it can share in many ways to produce the millions of organic compounds. One series of great interest is that of the hydrocarbons, i.e., compounds of hydrogen and carbon. It is shown how crude oil has long chain molecules, which must be broken up to produce high-octane petrol, by the so-called "cracking" process.

MODEL DISPLAY

The Atom

In this section of the exhibition are apparatus and other displays which describe the structure of the atom and its nucleus. One of the first displays is of a "Jacob's ladder," which illustrates an electric discharge rising with the heated ionised air up two diverging poles and finally assuming a length some twenty times its original before collapse. The principle of the discharge tube is explained with an arrangement of tubes with varying degrees of evacuation. Further cathode ray tube displays illustrate the classical experiments of J. J. Thomson and the behaviour of electrons are here demonstrated on seven different cathode ray tubes; a shadow of the Festival symbol cast upon the tube indicates that the electrons travel in straight lines. Because of the beam energy a small internal paddle can be seen turning, and when the electrons from a concave cathode are focused on to a piece of foil, the foil gets red hot. The fact that electrons can be deflected by electric and magnetic fields is shown on separate tubes, whilst on another tube can be seen the effect of applying these forces together. The description relates how this latter experiment enabled the charge of the electron to be compared with its mass, which Thomson calculated to be 1/1800 part of that of the hydrogen atom. With this evidence concerning the electron the narrative continues by illustrating the radio-active properties of some elements and the nuclear theory of atomic structure and its disintegration. Radio-activity of the element uranium, which was first observed by Becquerel, is shown on one display with the aid of an ionisation chamber, which is alternatively exposed to and shielded from a radio-active source by a lead screen. Another presentation shows the manner and extent to which the alpha particles spontaneously emitted from uranium are scattered when passed through a metal foil, an experiment from which Rutherford deduced that the atoms possessed positively charged nuclei and that they were relatively widely spaced. Alongside is an animated model of Bohr's hydrogen atom. The emission of gamma rays and beta particles from radio-active substances is also discussed.

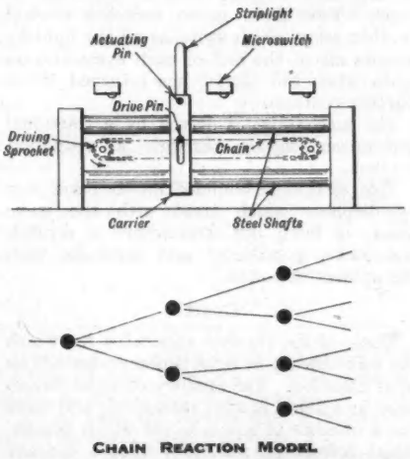
For the purpose of observing the tracks of charged particles emitted from radio-active substances two simplified Wilson cloud chambers are installed. The principle of the apparatus depends upon the rapid expansion of air in the cloud chamber to produce supersaturation conditions. The passage of the ionised particles through the chamber is then marked by water which condenses upon the tracks of the ions after their passage. The apparatus is fitted with a reciprocating piston, the head of which forms the floor of the expansion chamber. The piston is connected at its midpoint to a crank which is driven directly by a handwheel, by which expansions may be obtained at a rate of fifty to two hundred a minute. In order to dissipate the cloud formations to obtain a clear chamber after each expansion, an electrostatic field is set up in the expansion chamber. The radio-active substance is introduced on the end of a pin which fits into a tube in the glass cylinder. If it is desirable to reduce the velocity of the particles they can be passed through a thin foil introduced into the chamber.

Nuclear Physics

The subject of nuclear physics is treated with the aid of other animated displays of ingenious design. A demonstration of Rutherford's experiment in first splitting an atom shows the charged nucleus of helium, emitted from radium, bombarding a nitrogen atom which collects two neutrons and one proton from the helium nucleus, thus transmuting the nitrogen into oxygen with the emission of one proton. The later success of Cockcroft and Walton in 1932, working at the Cavendish Laboratory, Cambridge, is similarly depicted, whereby the ionised nucleus of hydrogen gathered from a discharge tube and accelerated by a voltage of 500,000V, was caused to bombard an isotope of lithium, each atom of which divided to form two helium nuclei. The loss of mass which occurs during this transmutation was found to be equivalent to the energy released, and in accord with the prediction contained in Einstein's theory of relativity, that mass and energy are convertible. J. J. Thomson showed that certain elements existed with different atomic weights, which suggested to Rutherford that within the nucleus there existed uncharged particles —the neutrons. The equipment with which Aston did the associated experimental work is illustrated; it is similar to that used earlier by Thomson. The ionised nuclei of an element when focused from the cathode of a discharge tube are deflected by an electric field and then a magnetic field, whence they strike a photographic plate having suffered different deflections according to their masses. By this method the isotopes of many elements were determined.

The final display in this section, designed and built by Max Models, Ltd., Terenure, Dublin, illustrates the basic principle of the chain reaction which occurs naturally in the uranium isotope 235.

When a neutron strikes the nucleus of a uranium 235 atom fission takes place and two or three more neutrons are produced. These neutrons themselves are involved in further collision with other atoms, whereby the so-called chain reaction develops with great release of energy. It is shown that, below a certain critical size, this process is not sufficiently sustained, as too many neutrons escape from the material without collision and a chain reaction is frustrated. Thus the fundamental requirement of an atomic bomb is to bring together two portions of the isotope, which singly were below the critical size for continued fission. The animated model depicts a neutron entering the nucleus of a uranium atom; fission of the nucleus into two (for simplicity); production of a flash on fission to simulate the release of energy; production of two or three neutrons from the fission which go on to produce further fissions. The illumination of continuous tracks was obtained by cutting slots in plywood and traversing a narrow-strip light behind them to produce the neutron paths shown in the accompanying diagram. To make the slots invisible the front of the model is covered with opal Perspex.

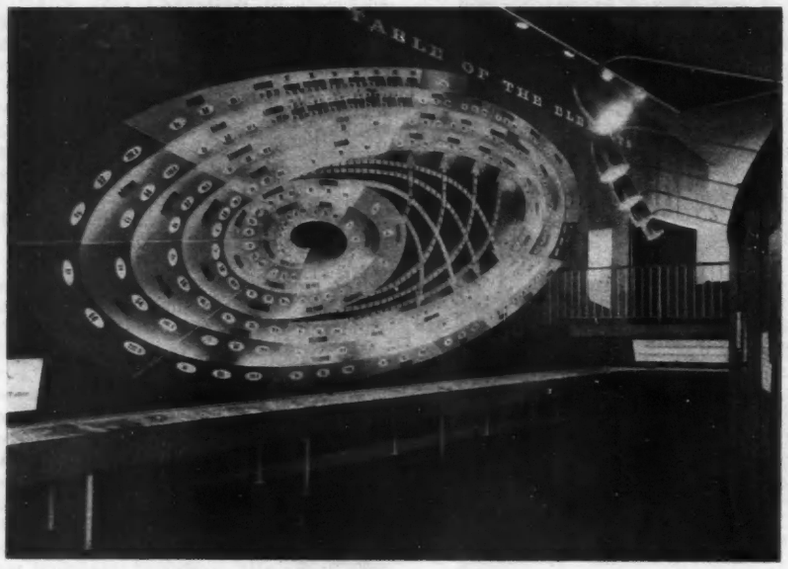


CHAIN REACTION MODEL

The uranium nuclei are simulated by a

coarse-mesh gauze illuminated from the rear, colour filters being incorporated to differentiate between protons and neutrons. The fission products are offset above and below the uranium nuclei, while the bulbs which produce the flash on fission are placed immediately before the uranium nuclei and shine through the neutron track slots.

The strip light is attached to a brass carrier which runs on two ¾in round steel shafts. The carrier is moved by means of a steel drive pin attached to a Reynold's chain. When the pin reaches a sprocket wheel it runs down a slot in the carrier, which then reverses. The continuous motion of the chain is thus converted into a constant velocity oscillatory motion of the carrier.



PERIODIC TABLE OF ELEMENTS

Operation of a bank of relays controlling the lights behind the various nuclei and the flashing lamps is by means of a series of micro switches actuated by a pin on the carrier. These micro switches are attached to a spring-loaded rod to ensure positive actuation by the pin. This control system ensures perfect synchronisation of the operations. Two more micro switches control another relay which switches all the lighting circuits off at the end of each cycle and on again when the carrier has returned to its starting position.

The mechanism is driven by a fractional horsepower motor through a reduction gearbox.

This section is bounded on its other side by displays which treat with the wave theory of light, the architecture of crystals and rocks, metallurgy, and concludes with the subject of colour.

LIGHT

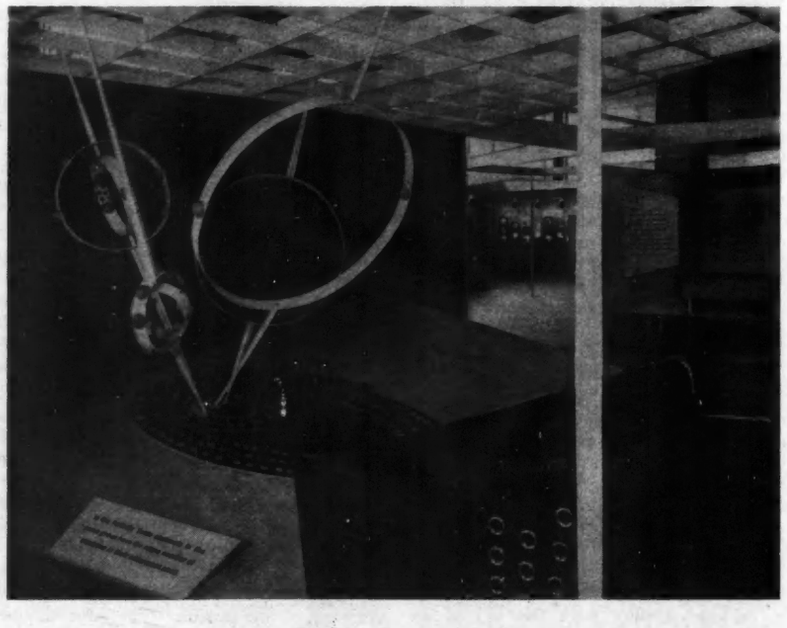
Much of the familar apparatus by which the wave theory of light is demonstrated has been installed. The analogy of wave formations in a liquid is used extensively and there are a number of ripple tanks which demonstrate refraction, reflection from a concave mirror and the particular case of diffraction through a grating. There is an experiment which shows light " bending " round a sharp edge, viz., a needle, which spreads and overlaps to produce a fuzzy shadow. Another illustration shows the dispersion of light when passed through a thin film, in this case a soap bubble, which has a thickness about equal to that of a wavelength of light. Among the microscopes exhibited there is described a compound reflecting microscope of high aperture for use in ultra-violet light, which is lent by B. K. Johnson, Imperial College of Science and Technology, and a universal electron microscope using four magnetic lenses, as made by the Metropolitan-Vickers Electrical Company, Ltd. A laboratory model of Schmidt Cassegrain telescope has been loaned by Dr. Linfoot, Cambridge University. An apparatus for investigating the distribution of thermal energy within the spectrum uses a thermo-couple placed at the focus of a concave mirror with which it sweeps from the ultra-violet to the infra-red ends of the spectrum; its energy is shown to be a maximum between these two ends.

There are other displays which demonstrate the phenomena of polarised light and its application to a method of stress analysis in structures known as " photo-elasticity." It is known that in many materials when stressed the crystals tend to orientate in the direction of the principal stresses at any point. In transparent plastics this tendency causes a marked rotation of the plane of polarisation of the crystals. The orientation of the plane of polarisation due to applied stress can therefore be observed in the form of fringes. Analysis of these fringe patterns enables the stress, providing it be two-dimensional only, to be very accurately determined. The display illustrates the stress distribution in a plastic model of a simply supported Warren girder. Upon the action of a simple rolling load system, loaded and unloaded members can be discerned, along with concentrations of stress. Much of this work was due to Coker and Filon, 1914. It follows, however, that the more important investigations of three-dimensional loading cannot be viewed in this simple manner, as superimposed planes being differently stressed in the third dimension, yield a resulting " scattered " light pattern, which cannot be related to any particular element. More recent developments have, however, yielded a new technique, in which the molecular orientation is retained after the stress has been released, so that the component can be broken down and examined " piecemeal "; and another technique depends upon an optical apparatus which can be focused upon a particular element within the material.

CRYSTALLOGRAPHY

The diffraction suffered by a narrow beam of X-rays when passed through a crystal and the symmetrical pattern produced is illustrated. These patterns were discovered by Von Laue and were used by Sir William Bragg to work out the structure of crystal compounds which are all based on one of seven basic symmetries. Many models and photographs are included in this section.

Photographs of the coloured crystal patterns, many of great beauty, particularly those of the granites, which can be observed when viewing ground elements 1/1000in thick through a microscope using polarised light, are reproduced. Nearby are geological scenes using sectioned models showing features of the earth's crust, the igneous and sedimentary rocks, faults, volcanic action, and the cooling and crystallisation of the mother liquor. One display uses superimposed panes of inscribed plastic in conjunction with sequential coloured edge



A TYPICAL STATIC MODEL

lighting to illustrate one theory of mineral deposition within the earth's crust. The molten substance is shown exuding into the sedimentary rocks, which are highly fragmented and folded, whereupon it cools and crystallises. The igneous rocks such as the granites thus formed forces the subsequent magna into both horizontal and vertical fissures, where the salts which it carries in solution solidify out according to their melting temperature, those with the highest temperatures solidifying first and consequently forming at the lower depths. The igneous rocks themselves differ in structure according to the manner and hence the rate at which they cool. The effect of weather action and other forces is illustrated. There are other photographs of typical granite scenery, and one shows the columnar jointing, similar to that in the Fingals caves, which results from contraction during sudden cooling.

Metals

The coherent theory which has now pertained for some twenty-five years on the structure of metals and their alloys is demonstrated by a number of other models and diagrams. Of the ninety-eight elements, over fifty are metals which almost without exception have at any one particular state one of three crystalline structures, the hexagonal close packed, face centred cubic and body centred cubic. Models of the atoms themselves show that metals have an outer shell containing from one to four valency electrons. The characteristics of metals, to which we have already referred, are accounted for and the application of heat, for instance, which induces the atoms to vibrate about their mean position, consequently increases the volume of the metal. It goes on to show the manner in which metals combine and the effect that atomic size has on alloying. It indicates, further, the work of Hume-Rothery, who about 1926 showed that there was a critical range of atom size ratios outside of which metals would not alloy. This ratio was about one-sixth. So that atoms which were not greater or smaller than one another by this ratio would alloy.

Colour

This section deals with the several ways by which colour is manifest. In one display are some of the pigments in Nature, and with them some synthetic dyes which match their structure in so far as they have practically the same "chromaphore." Some of the colour effects observed in insects and birds are not always the result of natural pigments, but result directly by diffraction of light; thus a peacock's feather can be seen which, when immersed in a suitable liquid, appears a dull monochrome.

Living Structure

The second major section of the exhibition uses similar display methods in depicting the structure and mechanism of life; it commences with a section on biochemistry and treats with cellular and multicellular organisms, the division of cells, reproduction and heredity forming an important part in the display. The exhibition concludes with a section which is aptly called "Stop Press." It deals with the latest theories and discoveries relating to the many subjects of the exhibition. There is a section on cosmic rays and tracks of cosmic particles can be observed with the aid of a Blackett cloud chamber. Other demonstrations are concerned with the universe, the energy of the sun and stars, and the creation of matter. It discusses the effect of proteins and their reproduction, and the ageing of living matter; these issues being but a few of those raised in this section. There is also an apparatus embodying the principles of the electronic calculating machine named "Nimrod" which plays the game "NIM" against a human opponent.

Apart from the displays themselves, there is a cinema in the exhibition, which provides a free programme of scientific films throughout the day. Amongst these films is one on cancer research and another deals with nuclear physics. The theme of the exhibition was devised by Ian Cox, and the captions are by Dr. J. Bronowski.

The 0·280in Calibre Weapons

TOWARDS the end of 1945 the need to provide a lighter rifle of the self load type became evident, and a panel was appointed at that time to investigate the best calibre, case and bullet characteristics for its development.

No lighter rifle could be produced if the 0·303in ammunition were to be retained, since the recoil on the shoulder when fired from a light rifle would be excessive. A new round, therefore, became the primary requirement. This condition provided an opportunity to dispense with the rimmed case of the 0·303in ammunition which had been in use since the latter half of the last century. Previously a rimmed case was no disadvantage, but with the advent of automatic weapons a rimless case is most desirable to reduce the number of stoppages during firing and to simplify the mechanism of the gun.

After prolonged and extensive investigation the panel established that a 0·280in calibre was ideal for general use. This calibre has now been adopted by the War Office and the new E.M.2 0·280 self-loading rifle introduced into the British Army. At a recent demonstration at the School of Infantry, Warminster, this equipment was demonstrated along with the existing 0·303in calibre rifle with which it was compared, and included in the demonstration was the 0·280in sustained-fire machine-gun, which eventually is to replace the Vickers M.M.G.

The characteristics of the 0·280in round permit a decrease of 12 oz in the weight of the unloaded rifle. In addition, the 0·280in cartridge gives an 18 per cent saving in weight when compared with the existing British 0·303in round. There is also a substantial decrease in length which, in turn, provides a considerable reduction in bulk on large quantities of ammunition. Following development work spread over three years, exhaustive trials have been carried out during the past eighteen months with ammunition and semi-automatic rifles in 0·280in calibre. It was shown that the incapacitating effect of 0·280in ammunition is ample to fulfil requirements and its powers of penetration at the limits of range required are considerably better than those of 0·303in. Despite these attributes the recoil produced by the 0·280in ammunition is 3·56ft-lb less than that of the 0·303in fired from the existing Service rifle.

It was shown also that the rate of armed fire was increased by at least three or four times; that when fired for accuracy it was superior to the 0·303in rifle; it was more dependable in conditions of dust and mud, and though easier to handle than the Service rifle, it withstood the full rigours of bayonet fighting.

The table given above provides a comparison of the two rifles.

At the firing range rapid fire and penetration tests of both rifles at various ranges were demonstrated. The object of another test was to show that any current small arms can be converted to 0·280in calibre. There was a comparison also of the tactical handling qualities of both rifles and finally a demonstration of the 0·280in machine gun.

THE 0·280 "E.M.2." SELF LOADING RIFLE

Particulars of 0·280 Self Loading Rifle

	0·303in Lee Enfield rifle	0·280in E.M.2 Self-loading rifle
Weight of rifle (less magazine, sling, &c.)	8 lb 11 oz	8 lb
Weight of magazine (empty)	5¾ oz	8¾ oz
Capacity of magazine	10 rounds	20 rounds
Overall length	44in	35in
Barrel length	25in	24½in
Sights	Conventional metal type	Optical
Action	Bolt operated	Gas operated
Rate of aimed fire (per minute)	15 rounds (by highly trained soldiers)	60 rounds (by recruits)
	0·303in ammunition	0·280in ammunition
Nature	Rimmed	Rimless
Weight of 100 rounds	5·43 lb	4·50 lb
Length of round	3·07in	2·54in
Bullet weight in grains	174	139
Recoil Energy (ft-lb)	11	7·44
Muzzle velocity	2465	2530

Missouri Valley Floods

(By Our American Correspondent)

RECENT dispatches from Kansas City and other points in the Missouri Valley tell the story of failure to tame a great river system. The Missouri is North America's longest river. It rises at Three Forks, Montana, near the Continental Divide, and flows almost 2500 miles before it joins the Mississippi just above St. Louis. The Missouri and its tributaries drain a valley of 530,000 square miles—one-sixth of the land area of the United States. Most of the Missouri Valley is farmland, the great plains which provide the country with a fifth of its cattle and almost half of its wheat. The Missouri Valley has endured great cycles of drought and flood. For example, rainfall was below average in every one of the years 1930 to 1939. In every one of the eleven years since it has been above average. Through the years, 6,000,000 acres have been subjected to floods. Erosion has been great; every year the Missouri, appropriately nicknamed "Big Muddy," is estimated to carry off 200,000,000 tons of soil. Until recent years there were only local efforts to solve the water problems of the Missouri Valley. Progress was retarded by local and inter-State quarrels over water rights and by unwillingness to spend the huge sums involved. In 1944 Congress approved the Pick-Sloan plan, a compromise arrived at between the U.S. Army Corps of Engineers and the Bureau of Reclamation, which has been called a "watered-down" substitute for a real Missouri Valley Authority. The Pick-Sloan plan calls for flood control, irrigation, navigation improvements, hydro-electric power development and conservation. But there is no central authority, projects are undertaken on a piecemeal basis, and Congress takes an interfering hand in every step. The result is that little progress has been made. Of 106 dams contemplated, only a dozen are finished or under construction. There has been continual bickering between the administrators of the plan, the Department of the Interior and the Corps of Engineers.

The Missouri Valley has now suffered one of its worst disasters by water. The lower Missouri and one of its chief tributaries, the Kansas, have been in flood. The Kansas itself is only 170 miles long, but it is fed by five tributaries which run across the entire breadth of the state. The disaster came as the result of extraordinary weather conditions. Usually, moisture-laden air from the Gulf of Mexico sweeps over the area, drops a small part of the water and heads for the north-east. But in the last few months the rain clouds have almost all been discharged completely over the Missouri Valley area. The tributaries of the Kansas River began overflowing in June. On July 9th, 10th and 11th great storms hit the area, and as much as 4in of rain fell in a day. On July 12th the Kansas River and its tributaries had record floods. On July 13th the high water on the Kansas River, flowing at the rate of 500,000 cusecs, reached Kansas City, flooding large sections of the town and sweeping into the Missouri. Damage in the states of Kansas and Missouri has been estimated at 900,000,000 dollars. More than 2,000,000 acres have been flooded, and 518,000 persons have been driven from their homes. A 25,000,000-dollar relief Bill has been rushed through Congress and signed by the President. But in the Missouri Valley there were demands for more than emergency relief—for a permanent answer to floods and droughts.

One of the late President Roosevelt's dreams was of an "Authority" to be created on each of the great river systems of the United States. The Tennessee Valley Authority has shown beyond doubt that Federal development of a river for multiple purposes can be made to operate successfully. If on the Tennessee, why not on other rivers? The Missouri River presents a tremendous challenge. What is needed is an agency, a Missouri Valley Authority, to reconcile the many different plans and projects which have been proposed for the river. The Pick-Sloan compromise, although it contains numerous worthy projects, is not and never was an overall plan for the entire river development. The very vastness of the problem has brought into action various interested groups in one field or another. Opponents of public water power do not wish to see such power developed on the Missouri. Those who are advocating irrigation do not see eye to eye with those whose interests lie in navigation or in flood control. The sectional interests of a dozen states are involved. But it does seem that the tragic object lesson of this flood must lead to a broader and more responsible approach to this whole subject. It will never be enough to check floods at Kansas City or at any other point. What is required is the beneficial use of an entire river running for many hundreds of miles through the very heart of America.

The Nuclear Reactor at the Brookhaven National Laboratory, New York

THE atomic pile at the Brookhaven National Laboratory, Upton, New York, which is now in operation, is the first reactor ever built in the United States exclusively for research purposes. It is extremely versatile and is believed to possess the greatest concentration of instrumentation ever installed in an atomic pile. It can operate at any level up to its 30MW capacity and has facilities for a number of different nuclear experiments to proceed simultaneously, each under the most carefully controlled conditions.

SITE WITH OVERHEAD TRAVELLING CRANE

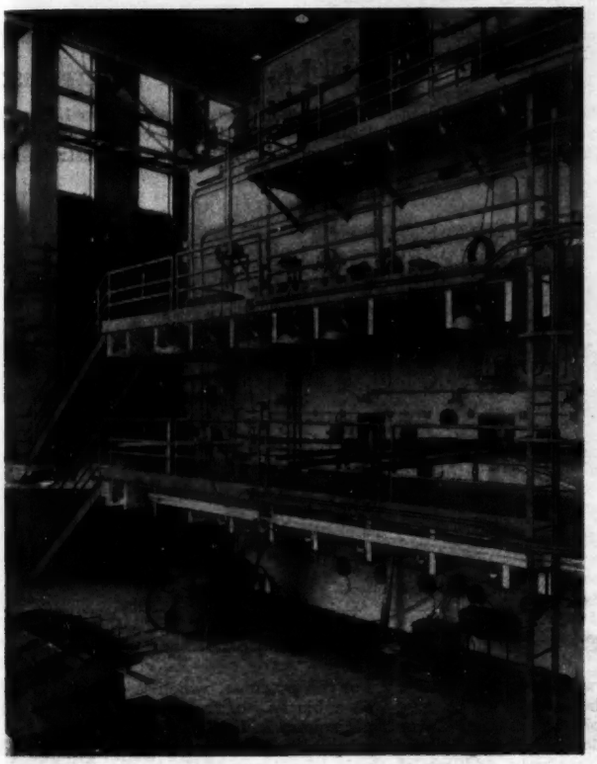
The Brookhaven pile consists of five basic elements: the graphite moderator, the uranium fuel, the control system, the concrete and steel shield and the cooling system. Uranium fuel encased in aluminium cartridges is inserted in one of the many openings in the loading face of the reactor. Operations of the reactor are controlled from a room equipped for the continuous recording of the power level, the neutron concentration and other essential data. Control rods containing boron are inserted or removed by remote control mechanisms, so that operation is flexible up to maximum power. To protect personnel from radiation the pile is surrounded by a shield of concrete and steel several feet thick. Other precautions for the protection of the operating personnel include heavy lead shielding, instruments for the monitoring of radiation levels whenever radioactive material is handled and the use of periscopes and remote controls to manipulate highly contaminated substances.

The Brookhaven establishment comprises five major structures, the largest of which is the reactor building. Two laboratory wings with a total of 30,000 square feet of floor area are situated on either side of the reactor building, and a "hot" laboratory nearby provides 33,000 square feet of floor area for research with high-intensity radio-active materials. Also in the vicinity is a fan house and a boiler house for heating and process steam.

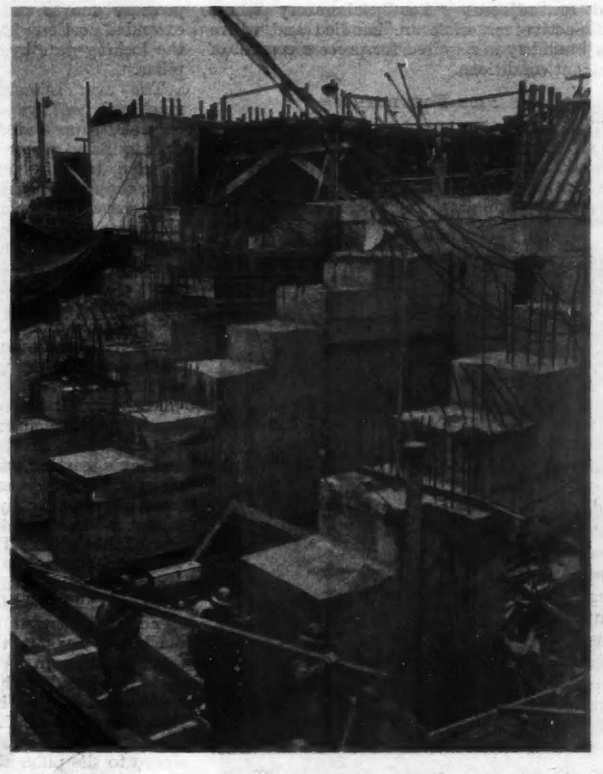
THE GRAPHITE MODERATOR

The moderator cube is composed of 60,000 pieces of graphite, stacked on top of each other, similar to building blocks. There are 2600 different sizes and shapes of graphite, and an individual drawing was prepared by the contractor for each of the 2600 variations. The machining of the graphite to tolerances of the order of thousandths of an inch was the responsibility of the contractor. It was considered desirable for security and other reasons to do this work at the construction site, and it was accomplished by a sub-contractor in a former Army gymnasium at Brookhaven. The gymnasium was equipped with a complex dust collecting system to remove graphite dust and to provide safe and satisfactory working conditions. As it was not permissible

to employ a bonding material between the individual blocks of graphite, it was necessary to use a comprehensive keying system, in which every piece is keyed either once or twice. The lack of a bonding agent also accounts, in part, for the close tolerances required to hold the structure together. Both external and internal forces had to be compensated for in the design of the graphite blocks. The external forces are considerable, due to the pressure drop required to provide the large volume of air used to cool the pile. Internal forces arise from the temperature differentials inside the graphite cube during the atomic reaction. The actual stacking of the graphite blocks had to be done under conditions regarded as extraordinary in the construction industry. Thus, it was necessary, for example, to prevent the contamination of the graphite units. The principal contaminating agent to avoid was borax, an ingredient contained in most laundry soaps. Therefore the workmen engaged in the stacking of graphite were provided each day with a pair of white overalls and with gloves laundered with borax-free soap. They were also furnished with basket-ball shoes to prevent slipping. The gloves were changed about six times daily to avoid accidents likely to result from accumulations of slippery graphite dust from the graphite blocks.



LOADING FACE OF PILE



CONSTRUCTION OF PILE FOUNDATION BUTTRESSES

Machining of Uranium

The machining of uranium presented many problems similar to those encountered in the fabrication of the graphite. The security provisions applicable to the handling of uranium required the metal to be brought to the site under armed guard and the smallest fraction of the material to be accounted for. Chips and grindings were always under the most careful control. As uranium is chemically very active, poisonous and, of course, radio-active, all machining equipment was provided with hoods and exhaust ventilation to protect the operators. All contaminated equipment had to be thoroughly cleaned or disposed of. On account of the extreme abrasiveness of uranium, cutting tools and inspection equipment were found to wear out very rapidly. Since the metal is rather heavy (1150 lb to 1200 lb per cubic foot), machining and storage were planned to involve as little handling as possible. Special cutting compounds were used to keep the uranium below the igniting point while being machined.

Pile Shielding

The pile shield, which encases the graphite cube on all sides to protect personnel from radiation, provided one of the most interesting structural aspects of the project. The shield is constructed of concrete, several feet thick, and steel plate ranging in thickness from 9in to 18in. The steel plate is used structurally as well as protectively, and is said to be one of the largest concentrations of armour plate ever used on a land-based building project for non-military purposes. It was obtained from surplus material available in the Panama Canal zone. The plate was fabricated by the New York Naval Shipyard in sections weighing approximately 10 tons each. To facilitate their erection at the construction site the builders planned their work so as to have a permanent 10-ton travelling crane in operation by the time the steel plate was ready to go into place. The crane girder has a span of 84ft and weighs approximately 11 tons. Because of its length and weight, a special study had to be made before a road transport route could be established from the New York Naval Shipyard in Brooklyn to the site of the pile. An illustration on this page shows one of the removable shielding blocks being lowered into place with the aid of the overhead travelling crane. The grooves in the steel plating indicate the overlapping method of stacking used. Many of the steel plate sections are pierced by holes for control equipment, slots for uranium charges and openings for experimental purposes. All openings had to be fitted with special plugs, to be inserted when the opening is not in use. The sections were stacked on top of each other in the case of wall shielding, and side by side in the pile base and top. They were electric arc-welded in place.

PLACING OF SHIELDING BLOCK

Pile Cooling System

To remove the considerable amount of heat generated within the pile during the fission process, an extensive cooling system was designed. In the fan house adjacent to the reactor building centrifugal compressors draw some 300,000 cubic feet of air per minute through the pile cooling system. There are five blowers, each driven by a 1500 h.p. motor at a speed of 3600 r.p.m. One of the air intake ducts is shown in the engraving overleaf. The method followed in the design of the fans is representative of the procedure carried out by the contractor in other phases of the project, such as instrumentation. Every effort was made to adapt existing industrial equipment to the requirements of the reactor. In this manner conventional items of equipment with modifications could be utilised, and the background of experience in manufacturing and operating this equipment could be put to use. The alternative of designing special equipment was avoided wherever possible. In the case of the fans the B. F. Sturtevant Division of the Westinghouse Electric Corporation co-operated with the contractor to adapt one of its standard products. This fan installation is said to be one of the largest in which a high-pressure ratio is achieved in a single-stage installation of air coolers on the suction side of the fans. The

design adopted allowed the temperature and volume of air to be kept relatively low with a resulting reduction in the size of equipment.

The air is filtered before it enters and after it leaves the pile. Dust is taken out before the air goes into the pile, and any dust which may have been picked up inside the pile is removed before it is expelled. The air is finally exhausted through a reinforced concrete stack, 320ft in height and tapering from 32ft diameter at the base to 19ft at the top. A silencer was built into the ducts and the base of the stack to eliminate noise. It was also necessary to install a secondary cooling system as the temperatures of exhaust gases from the pile are higher than the temperatures concrete can stand continuously. Refrigeration was required for the air conditioning of the pile building and control areas, the pile laboratory and an adjacent "hot" laboratory where radio-active materials are handled and where low humidity is required for process control of ambient conditions.

Pile Foundation

The foundation problems involved in the construction of the pile are of particular interest for two reasons. In the first place, the nature of the pile and the method of assembling the graphite blocks required the

Air Intake Duct

prediction of settlement and tilting of the foundation within very close tolerances. Secondly, the weight of the pile is so great that it causes stresses of about 1 ton per square foot at a depth of 100ft below the footing. The total weight of the pile—about 18,000 tons including the foundation—produces a soil pressure of 6500 lb per square foot under the footing. Total settlement, as well as differential settlement or tilting, had to be predicted and compensated for in advance. Prior to the start of detailed design of the pile, borings and load tests were made to determine the elastic properties and the load-settlement characteristics of the subsoil. Altogether the foundation extends 35ft below the surface. The predicted total settlement was of the order of 2in and actual total settlement was found to be 1¼in. This was compensated for at the top of the foundation by correcting for tilting and by building the pile base higher by the amount of the additional settlement to be expected. Since the foundation rests on sand, there was no plastic flow of the soil to contend with. An illustration on page 239 shows buttresses for the pile foundation in the course of construction.

The H. K. Ferguson Company, of Cleveland and New York, was responsible for the design and construction of the Brookhaven reactor. Professor D. M. Burmister, of Columbia University, New York, acted as foundation consultant.

A 5ft Radial Drilling Machine

We have received particulars of a 5ft radial drilling and boring machine now being manufactured by the Ajax Machine Tool Company, Ltd., of Halifax. This machine is designed for use with both high-speed steel and carbide-tipped tools.

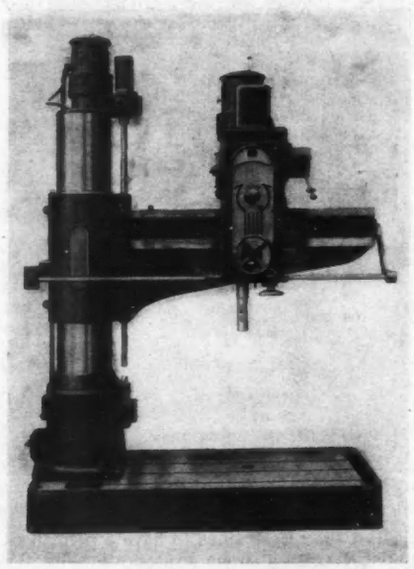
The heavy box form cast iron base-plate of the machine has tee slots machined on its upper surface for the attachment of work tables or large castings, and a bearing is provided in it for long boring bars. The pillar of the machine is fitted inside a heavy cylindrical cast iron sleeve which supports the arm. At its upper end the sleeve is suspended through a heavy ball thrust bearing on the pillar, and its lower end is fitted to the pillar base, where a combined ball and roller bearing takes the pressure due to the weight of the arm. The extended portion of the sleeve at its base carries the locking gear by which it is secured to the pillar.

The arm is carried on large accurately machined bearings on the sleeve on which it only slides up and down and does not rotate. An auxiliary motor at the top of the column is used to raise and lower the arm through a steel screw and phosphor-bronze nut. A cast iron safety nut fitted in the elevating gear automatically comes into operation if the bronze nut fails, and a friction device is incorporated to prevent overrunning.

In the saddle unit all gearing and mechanisms are totally enclosed in the main casting, and all spindle speeds and feeds are provided by a motor mounted at the rear of the saddle. The weight of the saddle is carried on rollers which have ball bearing spindles and travel on machined ways in the front of the arm. Vee ways machined in the lower part of the saddle register on a slide in the radial arm to give true alignment of the spindle. A single lever is used to lock the saddle to the arm and the sleeve to the pillar simultaneously, and, whilst the arm cannot be swung in this locked position it can be elevated or lowered.

The spindle is bored No. 4 Morse taper and it runs in hard phosphor-bronze bearings, the end thrust being taken in both directions by ball thrust bearings. Eight spindle speeds in three ranges are available, and four feed rates can be arranged with each of the speed ranges. The spindle has 14in of travel, and an automatic trip, which prevents overfeed of the spindle, can be set for cutting depths. A hand-wheel-operated slow feed can be used for fine settings of the spindle. Spindle speeds are selected by movement of a lever in a gate at the side of the head. The spindle start, stop reverse and inch motions are controlled by a specially designed switch on the saddle, and the arm-elevating and lowering movements are actuated through the same switch.

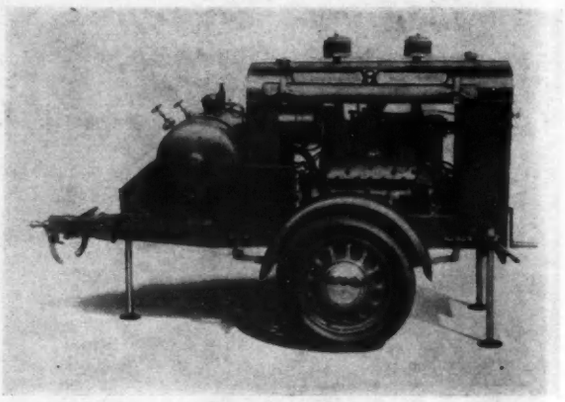
The machine has a mechanical lubricating pump and an independently motor-driven suds pump, which is mounted on the base-plate over a sump.



5ft Radial Drilling Machine

A Mobile Air Compressor

A mobile air compressor now being manufactured by C. H. Johnson (Machinery), Ltd., Adswood Road, Stockport, is illustrated below,



Mobile Air Compressor

For this machine, which is designed to deliver 55 cubic feet of free air per minute at 100 lb per square inch, the Ford V 8 engine has been adapted to form a combined engine-compressor unit. In it one of the banks of four cylinders has been converted into a compressor by the introduction of a special head, valve plate and induction manifold, whilst the other bank acts as the power unit.

The air intake of the compressor is through two air cleaners connected to the intake manifold, which is connected by flexible pipes to water-jacketed ports in the cylinder head. The compressor head is water cooled and the delivered air passes through water-jacketed passages in the cylinder block to obviate need for an after cooler. When required, the compressor cylinder head can be removed without disturbing the delivery air line.

An adjustable pilot valve fitted to the air receiver can be set for working pressures from 40 lb to 110 lb per square inch. At the predetermined pressure this valve allows air to pass to the idling control, which overrides the governor and shuts the throttle to idling speed. At the same time, air passes to pistons situated over the compressor inlet valves and holds these open, so that no further air is delivered to the receiver until the pressure drops sufficiently to close the pilot valve. The pilot valve is normally set to cut out at 100 lb per square inch.

The unit, complete with all auxiliary equipment, radiator, canopy, air receiver and toolbox is mounted on a light fabricated steel chassis fitted with tow-hitch and overrun brakes. In this chassis the axle is mounted on rubber blocks instead of the usual springs, an arrangement which is stated to give minimum sway whilst towing and to provide the necessary cushioning of road shocks transmitted by the axle to the chassis.

A Mobile Workshop

INCLUDED in the entourage which accompanies the British Racing Motors' projects to all meetings is a large and fully equipped Commer mobile workshop, shown below, which is being prepared to support the cars during their forthcoming continental appearances in Italy and Spain.

Mounted on a Commer "Avenger" chassis with six-cylinder, 109 b.h.p. "under-floor" engine, the workshop, equipped to carry out efficiently all conceivable running repairs on the spot, embodies a special steel sub-frame accommodating an auxiliary engine and generator on the nearside, with a compressor unit and pressure tank on the offside. A large panel on the nearside, hinged at the top, can be raised to give light and visibility to bench fitters, and at the same time forms a protecting canopy in inclement weather. Special equipment includes a lathe mounted direct to the metal sub-frame, acetylene welding apparatus, grinder, bench drills, work benches, bins, shelved small-tool lockers, &c., whilst six strategically placed 230V fluorescent tubes provide adequate interior lighting where electric mains are available. A 24V system, fed from two large 12V batteries under the floor, provides emergency lighting.

The bodywork on this mobile workshop was supplied by Rootes, Ltd., of Birmingham.

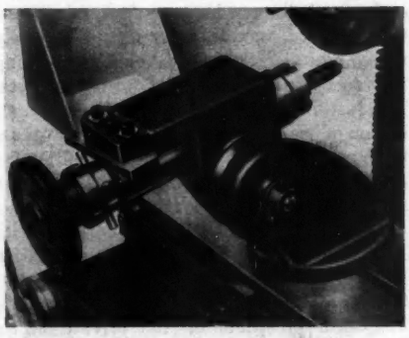
MOBILE WORKSHOP

A Tap Coning Attachment

WE illustrate herewith a simple attachment for grinding the taper lead of taps with taper relief in the lands which is made by Alfred Herbert, Ltd., of Coventry, and known as the "Tapconer." It is suitable for use on one of the maker's "Junior" surface grinders or similar machines, and is fitted with a collet chuck which takes adaptors for holding taps from ¼in to ⅝in.

As can be seen from the illustration, the base-plate of the attachment is bolted to the machine table and carries a bracket in which is carried a spring-loaded spindle fitted with a split collet for the tap. The bracket swivels in a vertical plane and is marked with graduations numbered 1, 2 and 3 for setting it to the required angle for grinding first, second and bottoming taps respectively. A fluted knob controls the combined rotary and linear motions of the spindle through an adjustable straight-line cam and a collar which has three or four projecting pins corresponding to the number of flutes on the tap. The cam plate carried on the bracket overarm, which swivels on a central pivot and is clamped by two screws, can be set to determine the amount of relief on the tap. For setting to the correct relief, four index marks are engraved on the top left-hand surface of the cam plate, two marks for right-hand and two for left-hand taps.

When setting the attachment the tap is rotated in the collet until one cutting edge and the opposite heel edge are in a horizontal plane before the collet is locked on the tap. The right-hand table stop of the machine is then set so that the tap is directly under the grinding wheel and can be moved to be right if desired for inspection. The table is then raised to put on the required cut and the fluted knob is pulled forward and for a right-hand tap, rotated clockwise allowing the pin to ride down the face of the cam until the next pin is touching the underside of the cam. The process is then repeated until all lands have been ground. If necessary, the table is raised to increase the cut and the entire operation repeated. This method ensures grinding from the cutting edge to the heel of the land.



TAP CONING ATTACHMENT

It may be considered more convenient to rotate the knob in an anti-clockwise direction as the knob need not then be pulled out to reset the pin on the cam. If this is done care must be taken not to allow the grinding wheel to dwell on the cutting edge of the tap.

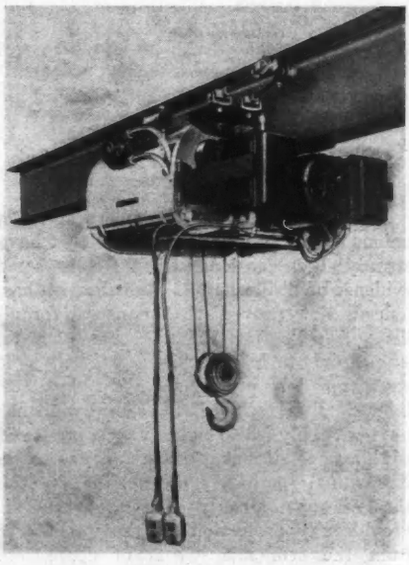
Spiral taps can be ground by setting the attachment so that the axis of the wheel spindle is approximately in line with the spiral angle of the tap. If the chamfer of the tap is longer than the width of the wheel, the attachment can be set so that the spiral angle is in line with the length of the table.

A Fluid Drive Electric Hoist

FOLLOWING the adoption some years ago of a fluid drive for the travel motion of its "Lo-Hed" hoists, the Taylor Stoker Company, Ltd., of 189, Drummond Street, London, N.W.1, has recently developed an improved design which has greatly reduced the amount of headroom occupied by the hoist.

The earlier model was mounted on a load bar for the suspension of the complete trolley, which was rather cumbersome and costly. In the new design, shown in the accompanying illustration, the trolley drive is built into the frame of the standard hoist. With this design the height between underside of beam and inside of hook, when at the top of its lift, has been reduced to give an 8in additional lift height.

The electric motor drive for the fluid transmission is coupled inside the hoist to an oil pump which is connected by copper piping to the oil motor on the left-hand side of the unit. This oil motor is coupled to the shaft of a driving pinion meshing with a pair of the trolley wheels. The fluid drive units are rotary vane pumps, designed for reversible operation, and the transmission is a closed circuit fitted with a make-up tank and non-return valves.



FLUID DRIVE ELECTRIC HOIST

No brake is necessary on the electric motor since the transmission automatically forms its own brake, from the pressure in the system. There are no levers or reversing valves to be operated, and the drive is reversible simply by pressing the appropriate button on the pendant control.

The standard travelling speed, for hoists up to 3 tons capacity, is 100ft per minute, but other speeds can be accommodated by varying the eccentricity of the pump rotors, if required. The hoist can be operated, for hoisting and for travelling, either by pendant push buttons or by remote push buttons at any number of points, or a combination of both, dependent upon requirements.

THE ESCALATOR IN THE DOME OF DISCOVERY.—Our attention has been drawn to a misleading statement in the second paragraph of the article describing the escalator in the Dome of Discovery at the South Bank Exhibition, which appeared in the issue of August 3rd. J. and E. Hall, Ltd., points out that the Standard Steel Company, Ltd., was responsible for the manufacture and erection of the steel structure only. The design and general manufacture of the remaining engineering equipment of the escalator was carried out at Dartford and erected by the staff of J. and E. Hall, Ltd., and that company was responsible for carrying out the complete installation.

THE ENGINEER

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NATIONALISING THE ENGINEERING INDUSTRY

AMONGST leaders and members of trade unions operating within industries that have already been nationalised there is some evidence of disillusion. Nationalisation has, indeed, not proved that panacea for all ills which the men, if not their leaders, supposed it to be. It has created at least as many new problems in, for instance, labour relations, as it has solved and has not necessarily led to higher wages, improved working conditions, or greater security. Nor, as perhaps the situation on the railways already illustrates, can it provide any protection for the workpeople from the economic effects of depression. Enthusiasm, however, remains unabated elsewhere. Last week, for instance, at its annual meeting at Swansea, the Confederation of Shipbuilding and Engineering Unions adopted a "Plan for Engineering," which amounts to a tentative scheme for bringing large sections of that group of industries under either public control or full public ownership. That plan will now be submitted to the Trades Union Congress for approval and possible adoption as T.U.C. policy.

Unquestionably one of the objects of such a policy is that of increasing the influence of the unions in the management of the sections of the engineering industry concerned. Indeed, for at least one section, that of motor-car manufacture, the only argument of weight, advanced in the plan, for the establishment of a "Development Council" is the "quite insufficient . . . expression of the trade union or general public interest in the conduct of the industry." All other arguments advanced in relation to what is a highly prosperous, highly productive and highly efficient industry amount only to the naive one that there might be justification for interference with its management some time in the future if it failed to maintain present standards! In other fields a wide variety of reasons are adduced for imposing some form of national control. The aircraft industry should be nationalised because of its "almost complete dependence on the State or State agencies for its business and finance," a reason that neglects to see that governmental agencies are not only not always right, but can be quite frequently wrong; and that, therefore, even the limited freedom of private firms to take risks in developing "unauthorised" craft may well prove as valuable in future as it has in the past. The suggestion that the production of builders' and domestic castings and metal fittings should be put under public ownership because "monopolistic arrangements and restrictive practices have held undisputed sway for many years" reveals the trade union suspicion that such trade "rings" exist primarily to maintain unduly high profits, a suspicion by no means always justified. The manufacture of mining machinery, it is argued, should be brought under the wing of the National Coal Board because that Board should have better workshops. The Confederation is strangely blind in seeing "no apparent reason why exports of mining machinery should suffer" thereby when in fact, of course, the Board would necessarily be only really interested in developing mining machinery suitable to its own purposes. The justification for suggesting the nationalisation of heavy electrical engineering appears to lie very largely in a suspicion that BEAMA acts as a monopoly "ring." The private manufacture of locomotives only escapes a proposal for complete "co-ordination" with British Railways workshops—a suggestion likely wholly to ruin an important export industry—because "it may be felt that the long-term prospects of the private sector of the industry are not particularly bright"! A development council is proposed instead. Nationalisation is proposed for the machine tool industry (not, it must be admitted, without an expression of doubt as to its wisdom "until such time as there is greater public control over other sections of the engineering industries"), because "the fact that by far the greater number of firms in the industry are small means that inevitably a considerable section of the industry does not possess the resources to undertake . . . necessary research and development"; and because skilled labour is "employed in small inefficient plants which the industry can ill afford to continue." And so on. Outside those fields of union activity that have felt the shock of nationalisation, to judge by this plan, there has been strangely little change in trade union thought these last ten years. Nationalisation is still believed to be a panacea. Whatever is wrong with industry in private hands can be put right by bringing it under public control!

The criticisms of private industry implied by such proposals for nationalisation are, of course, not without foundation. It is true that the private interest of a firm usually conforms to the public interest, for that it is prosperous and efficient benefits not only its shareholders, but its workpeople and the nation at large. But it is not a law of nature that private and public interest so coincide and it is, for instance, certainly arguable whether certain monopolistic practices have benefited the public. What is, however, a non-sequitur is to suppose that "nationalisation" will ensure that the public interest alone is served. For even if the Government may be presumed to have sufficient control to prevent those in the industry (management, men and unions) serving their own new monopolistic interests first and the nation's second, can it really be claimed without qualification that a Government has not interests that will be in opposition at least to the interests of a very large section of the public? Nor does the placing of a whole industry under a single authority necessarily lead to efficiency, a fact discovered soon after the first world war during a period when, for reasons not at all unlike those now advanced in favour of nationalisation, there was a fashion for "rationalisation" a policy that proved far from unrelievedly successful. For though small firms lack certain of the advantages of large ones, they are not without other advantages consequent upon their more intimate organisation. Some machine tool firms may, it is true, be inefficient, as the plan complains. But it is not necessarily true to assume that they are inefficient because they are small. The engineering industry is, as a whole, largely made up of small firms, many of which (if not, in fact, most) are just as efficient as their larger brethren. We do not believe that nationalisation or rationalisation would improve their prospects. For our part we would prefer to see continuing that evolution that, in response to need and to criticism, has led to the creation of such bodies as the British Standards Institution, the D.S.I.R. research laboratories, and industrial associations for research for marketing, for standardisation, and the like. By a similar evolutionary process we believe that eventually there will be found a satisfactory means of associating workpeople with management without offending the canon that men should work and managements should manage. Indeed there is plenty of evidence that such a process of evolution is already operating.

AIRCRAFT CARRIER DESIGN

THE modernisation of our six existing fleet carriers now in hand and the frequent alterations necessary in the design of the carriers under construction since the war are the direct consequences both of the elimination of potential enemy battle fleets and carriers and of the constantly increasing size, weight and speed of modern aircraft. Before the last war carriers were required

to operate aircraft capable of overcoming the opposition of enemy carrier aircraft, while endeavouring to locate the enemy battle fleet and reduce its speed by torpedo bomber attack. The aircraft of both sides were thus restricted by the same conditions. They were compelled to operate from carriers and it was a comparatively simple problem for our naval constructors and engineers to design vessels which in performance and other operational requirements were at least as good, if not superior, to those of a potential enemy. Under modern conditions, however, the primary function of our carriers has entirely changed. Though naval aircraft are still essential for general reconnaissance duties and anti-submarine operations, British carriers will in future be required to form part of Task Forces and to provide air cover for expeditionary forces while on passage and during the landing until air bases can be established ashore for land-based aircraft. Moreover, whether or not naval aircraft are to assist the Royal Air Force in strategic bombing, there are likely to be many opportunities for medium range bombing from carriers operating off the enemy's coast. All these duties will entail opposition from enemy shore-based fighters and it is thus essential that we should have up-to-date naval fighters in addition to the fastest and most powerful bombers, offensively and defensively, which it is possible to operate from carriers.

The ratio between the length of useful life of a carrier and that of the types of aircraft she is designed to operate may be taken as about 4 to 1. Hence the importance of naval constructors forecasting possible aircraft developments a long way ahead and the need for major alterations, involving an increase in strength of the flight deck and the installation of higher performance arrester gear and catapults and other important modifications, both to existing carriers and carriers under construction. This is well illustrated by our two large fleet carriers of 36,800 tons, now under construction. The "Eagle" will be completed and join the fleet very shortly, but her sister ship, the "Ark Royal," whose construction was started only six months later, is to have her completion date adjusted to provide for still more modern equipment to be installed in her. She is not likely to join the fleet before the end of next year at the earliest. In the circumstances the six 13,000-ton light fleet carriers of the "Glory" class can no longer be regarded as having any real value for fleet work. Laid down in 1942, at a time when the urgent need for both repair and new construction of merchant ships imposed rigid economy in naval building, they were regarded as makeshift carriers intended to meet immediate fleet requirements in the Japanese war. The "Triumph" and other ships of the class have since done excellent service in Korean waters, but already they are stretched to the limit in being called upon to operate aircraft of a weight half as heavy again as those of six years ago and with take-off and landing speeds some 30 knots in excess of their predecessors of that time. Apart, moreover, from the small number of aircraft carried—about forty—their maximum speed of 23½ knots is insufficient for operating jet and other modern aircraft and it is no doubt this reason why work has been discontinued on the construction of the three similar 14,000-ton carriers of the "Hercules" class, laid down in 1943. The decision may well have been forced on the Admiralty, in view of the very considerable building programme provided for under the rearmament proposals. For, in addition to the construction of several anti-submarine and mine sweeping vessels, the four 30-knot "Hercules" class carriers are being completed for fleet work. None the less, it is a regrettable decision, for the three slower carriers would be extremely useful as convoy escort carriers.

In the second world war some forty-five escort carriers, of about 9000 tons displacement, with a speed of 16 knots and constructed on merchant ship hulls, were obtained from the United States. They accompanied convoys throughout their voyages, one carrier per convoy, and they did noble work in keeping U-boats submerged and preventing them shadowing a convoy on the surface and attacking in packs at night. But concurrently with the increase of the submarine's offensive power as the result of the Snort and increased submerged speed, aids to aircraft in anti-submarine warfare have made rapid strides. The weight and size of both detecting devices and anti-submarine weapons now being installed in aircraft have increased to such an extent since the war that the modern anti-submarine aircraft will be incapable of operating from escort carriers with the small dimensions and limited speed of those used in the last war. The escort carrier of the future will require to be a ship of approximately the size, speed and performance of the "Glory" class and it will not be easy to find merchant ships of this type for conversion, in view of the demands for shipping in war. But there is a silver lining to the cloud in the prospect of being able to fit carriers with a flexible rubber flight deck. Jet fighters have already landed both by day and by night on the flexible deck fitted for experimental purposes in a "Glory" class carrier, and though details are still on the secret list it is known that the experiments since carried out have given promising results. Landing on a rubber deck will dispense with the need for the undercarriage which takes up a percentage of the total weight of an aircraft out of all proportion to its value. If, indeed, the project proves successful, it will very greatly increase the effectiveness of the naval air arm; both by reducing the performance requirements of escort carriers and enabling fleet carriers to operate aircraft of increased range, armament and performance. Undercarriageless aircraft will, of course, require to be catapulted to become airborne, but this is little, if any, disadvantage. Catapulting is now becoming the standard method of launching all our latest aircraft. It increases slightly the interval between the launching of individual aircraft, but, on the other hand, it gives a carrier the immense asset of greater tactical freedom, as she has no longer to alter course into the wind prior to flying-off. After flying-off two or three flights of aircraft during the last war, when the catapult was little used, a carrier would often find herself several miles away from the protecting force of surface ships to which she was attached and thus an easy prey to attack by submarine or even surface warships. Steaming into the wind for landing on, will still be necessary but there is normally sufficient notice of this requirement for action to be taken to adjust the position of the carrier. The tactical freedom given by the use of the catapult may, indeed, be regarded as an effective answer to the argument that the large fleet carrier is too vulnerable to be counted on as a safe means of support for the landing of armies and air forces.

Obituary

HENRY ROBB, J.P.

It is with regret that we announce the death of Mr. Henry Robb in an Edinburgh nursing home, after a long illness, at the age of seventy-six. Mr. Robb was chairman of Henry Robb, Ltd., the well-known firm of shipbuilders which he founded at Leith, in 1918. He was born in Glasgow in 1876 and was apprenticed to a company now known as the Ailsa Shipbuilding Company, Ltd., attending the Ayr Academy to gain his technical knowledge in naval architecture.

In 1901 he went to Greenock as assistant foreman plater. Promotion was rapid, and within a very short space of time Mr. Robb was appointed shipyard manager to George

HENRY ROBB

Brown and Co. (Marine), Ltd., which position he relinquished in 1914 upon taking over a similar post with Ramage and Ferguson, Ltd., the old-established yacht builders of Leith. Four years later he decided to found his own business, which was, in the course of years, to develop into the extensive shipbuilding business with a worldwide reputation of to-day. Initial activities were confined to repair work with new construction being added subsequently, and, depite the depression during the post-war years, the new firm made progress, absorbing the small two-berth Hawthorn yard in 1922 and the adjoining Cran yard, with three berths, shortly afterwards. Under Mr. Robb's guidance and by his skill as a shipbuilder the firm continued to prosper, and in 1936 the company were in a position to be able to acquire the business of Ramage and Ferguson,

Ltd., and co-ordinate all the facilities into an efficient shipbuilding unit.

The coming of age of Mr. Robb's venture into shipbuilding and the fiftieth anniversary of his entry into the industry occurred in 1938, and at the celebrations it was stated that the company had delivered 280 ships. Mr. Robb was the recipient of worldwide congratulations on the occasion of his company's silver jubilee in 1943, and in 1947 he was presented with his portrait in oils by his fellow directors. Early in 1949 Mr. Robb suffered a severe illness, which prevented him from carrying out his duties as managing director, these being eventually undertaken by his son, although he retained the chairmanship of the company.

Mr. Robb, who was member of various harbour and other trade bodies of Leith, was elected a member of the Institution of Naval Architects in 1920 and served as a Member of Council for a few years from 1942 onwards.

G. HOWARD HUMPHREYS

We deeply regret to have to record the death of Mr. Guy Howard Humphreys, M.A., which occurred, suddenly, at Reading, on Monday last, August 20th. Mr. Humphreys, who was fifty-five, was a partner in the consulting engineering firm in Westminster, established by his father, the late Mr. Howard Humphreys, M.I.C.E.

Guy Howard Humphreys was educated at Westminster School and at Trinity College, Cambridge. He served an apprenticeship with Robey and Co., Ltd., Lincoln, and with Chance and Hunt, Ltd., Oldbury, prior to joining the family firm. During his early years in practice he was concerned with the design of a railway line for the British Dyestuffs Corporation, Ltd., Blackley, Manchester, where he acted as resident engineer. Subsequently he served as resident engineer on the main drainage scheme of Georgetown, British Guiana. Mr. Humphreys became a partner in the firm of Howard Humphreys and Sons in 1925, since when he had regularly advised on water supply and drainage problems both in this country and abroad.

Mr. Humphreys was elected an associate member of the Institution of Civil Engineers in 1922 and transferred to full membership in January, 1931. He was a Member of Council of the Institution and a recipient of a Miller Prize and a Telford Premium. He was also chairman of the Engineers' Guild, a past-president of the Institution of Sanitary Engineers and a past-chairman of the Association of Consulting Engineers. In addition, Mr. Humphreys' wide experience as a civil engineer was extremely valuable in public affairs. He was a member of the Westminster City Council and, for a term, chairman of its works and traffic committee.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

MECHANICS APPLIED IN ENGINEERING

Sir,—Despite the amount of research work that has been carried out on subjects connected with mechanical engineering, there are many simple questions that a designer might ask and fail to receive any satisfying answer unless he happened to know an expert in the particular field concerned. Plain bearings have been run in laboratory conditions under a constant load equivalent to 500 lb per square inch at a surface speed of 12,000 f.p.m.; is it advisable to design for such a pressure in actual service? If not, why not, and what is the highest safe working pressure? What bearing pressure can be allowed on case-hardened steel pins working in hardened steel bushings and what is a likely rate of wear? Is there any relation between the coefficient of friction in such a bearing and the finish of the working surfaces? The bending stress normally allowable in gear-teeth made from 60-ton nickel chrome steel can be determined with reasonable accuracy from the appropriate British Standard Specification, but how much higher might the stress be if only a few thousand applications of load will be made during the life of the parts? How does one proceed to identify and to suppress the source of vibration in high-speed machinery?

Reliable answers to many questions of this character are not easily discovered by anyone without some special experience in the field concerned and there seems consequently to be scope for a course of instruction designed to bring engineers as nearly up to date as possible in such matters.

Endeavours to find rational solutions to design problems by examining practice or the results of research work are often halted by some gap in existing knowledge that a moderate amount of experiment might fill. An effort to provide reliable guidance for designers by examining theory and practice with that end in view and by instituting research work where necessary seems worthwhile and the School of Applied Mechanics at Sheffield University is now planning it.

The basic aim is to offer advanced instruction to men who have shown by their work in the engineering industry that they are capable of applying technical knowledge to good effect in design and development. The subjects contemplated include lubrication, reduction of vibration and noise, principles of design of mechanisms, theory and practice of stress determination by modern techniques, selection of materials for long or short life and general procedure in engineering research and development.

Based on opinions from a wide range of industrial organisations, the list of subjects is thought to be sound, but it may be modified, and any suggestions from engineers will be welcomed.

W. A. Tuplin, D.Sc., M.I.Mech.E.
Professor of Applied Mechanics.
University of Sheffield,
St. George's Square, Sheffield, 1.

THE SAMPLE SIZE FOR A QUALITY CONTROL CHART FOR PROPORTION DEFECTIVES

Sir,—Given a control chart for proportion defectives p, with control limits $p \pm 3\sqrt{\frac{pq}{n}}$, where $q=1-p$, to find the sample size n such that the probability is k that a deterioration of the product from p to $p+\varepsilon$ is detected with the first sample drawn from the deteriorated product.

We denote by

$$P(p' \geqslant A \mid p+\varepsilon)$$

the probability that the sample proportion defective p' is greater than A, if the sample is drawn from a population with proportion defective $p+\varepsilon$.

The problem then consists in finding n such that

$$P\left(p' \geqslant p+3\sqrt{\frac{pq}{n}} \;\middle|\; p+\varepsilon\right)=k \quad . \quad . \quad . \quad (1)$$

If n is sufficiently large p' may be regarded as normal with mean $p+\varepsilon$ and *S.D.* $\sqrt{\frac{(p+\varepsilon)(q-\varepsilon)}{n}}$. A value t may then be found from the normal tables such that

$$P\left(p' \geqslant p+\varepsilon+t\sqrt{\frac{(p+\varepsilon)(q-\varepsilon)}{n}} \;\middle|\; p+\varepsilon\right)=k \quad . \quad (2)$$

Comparing (1) and (2), we have the condition

$$p+\varepsilon+t\sqrt{\frac{(p+\varepsilon)(q-\varepsilon)}{n}}=p+3\sqrt{\frac{pq}{n}},$$

which gives

$$\varepsilon\sqrt{n}=3\sqrt{pq}-t\sqrt{(p+\varepsilon)(q-\varepsilon)} \quad . \quad . \quad . \quad (3)$$

and n may be calculated for any given values of ε and k.

Example.—To find the sample size n such that the probability is 0·9 that a deterioration from p to $p+\varepsilon$ is detected with the first sample drawn from the inferior product.

The normal tables give here $t=-1\cdot28$, so that

$$\varepsilon\sqrt{n}=3\sqrt{pq}+1\cdot28\sqrt{(p+\varepsilon)(q-\varepsilon)}.$$

If $p=0\cdot04$ $\varepsilon=0\cdot05$, we have

$$0\cdot05\sqrt{n}=3\sqrt{0\cdot04\times0\cdot96}$$
$$+1\cdot28\sqrt{0\cdot09\times0\cdot91}=0\cdot954.$$

Therefore

$$n=364.$$

A case of special interest exists when $k=\frac{1}{2}$. The problem can in that case be worded as follows:—

Let p be the proportion defective of the original population and $L=p+\varepsilon$ the "quality level" or "level of indifference" (i.e., $p+\varepsilon$ is the proportion defective of a population for which there exists complete indifference as to acceptance or otherwise of the product). We have then

$$P\left(p' \geqslant p+3\sqrt{\frac{pq}{n}} \;\middle|\; p+\varepsilon\right)=\tfrac{1}{2},$$

or $k=\frac{1}{2}$, which gives $t=0$.

Formula (3) then becomes

$$n=\frac{9pq}{\varepsilon^2}.$$

Example.—If $p=0\cdot04$, $\varepsilon=0\cdot02$, we have

$$n=\frac{9\times0\cdot04\times0\cdot96}{0\cdot0004}=865.$$

H. Weiler
Sydney, Australia.

THE CONSERVATOIRE NATIONAL DES ARTS ET ATELIERS

Sir,—Your learned contributor in his article, printed in your impression of August 10th, omits to tell us that the venerable building, so well described by him, housed forty-six years ago a Wicksteed testing machine, at that time the largest universal machine of its kind and built by Joshua Buckton and Co., Ltd., of Leeds (quorum pars).

Frank B. Nathan
Westminster, S.W.1,
August 17th.

BOOKS RECEIVED

Advanced Mathematics for Technical Students. Part II. By H. V. Lowry and H. A. Haydew. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 18s.

Reports on Progress in Physics: Vol. XIII (1950). Edited by A. C. Strickland. London: The Physical Society, 1, Lowther Gardens, Prince Consort Road, S.W.7. Price 50s.

Pocket Book for Miners and Metallurgists. Fifth edition. Compiled by Frederick Danvers Power. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, W.C.2. Price 25s.

Transformers, Their Principles and Design for Light Electrical Engineers. By F. C. Connelly. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, W.C.2. Price 35s.

Crude Oils: Chemical and Physical Properties. Edited by Dr. Benjamin T. Brooks and Dr. A. E. Dunstan. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 48s.

Verein Deutscher Ingenieure Meetings in Hanover

THE eighty-first annual meeting of the Verein Deutscher Ingenieure took place in Hanover from Monday, July 30th, to Friday, August 3rd. This is the fourth time since the foundation of the Verein in Alexisbad, in the Harz, in 1856, that Hanover has been chosen for this purpose. This year the choice was a particularly happy one, because the "Constructa" Building Exhibition and the Garden and Horticultural Exhibition are now being held in that city. In June last, the number of members of the Verein had risen to 22,300, and more than a thousand members and guests from all parts of Germany and from abroad attended the meetings. The first meeting of the Council was held on Monday morning, July 30th, and the same evening an informal reception of members and guests took place in the restaurant of the main station.

On Tuesday the principal sitting of the Council took place in the New Rathaus, and during the morning and afternoon the first sessions for the reading of technical and scientific papers, of which there were some twenty-four, were held in the Stadthalle. On Tuesday, July 31st, a "welcoming evening" arranged by the Hanover Branch of the V.D.I., was held in the Main Restaurant of the Fair Grounds, at Hanover–Laatzen After the address of the President of the Hanover Branch, a programme of music and dancing was offered by the members of the Niedersächsischen Landestheaters, and after the concert there was a dance.

The principal meeting took place on Wednesday, August 1st, at 10.30 p.m., in the Niedersächsenhalle, and was preceded by the annual general meeting of members. The main meeting was opened by the playing of Weber's Overture to "Euryanthe" by the Niedersächsische Symphony Orchestra, under the leadership of its principal conductor, Dr. Thierfelder.

In his opening address, the President of the V.D.I., Director Hans Bluhm, of Düsseldorf, welcomed the representatives of the Government and the occupying forces, and also the delegates from foreign engineering institutions and scientific societies. He reviewed the activities of the Verein, and made special reference to the work it had done, and the efforts it had made, to raise the status of the engineering profession. Last year, we may recall, special meetings were held in Kassel, when the theme of "The Responsibility of the Engineer" was discussed. Earlier this year a similar meeting took place at Marburg University, when the subject considered was that of "Man and His Work in a Technical Age." The President also welcomed the revival of the German Committee of the World Power Conference, and the protection to German invention given by the establishing of a German Patent Office. He wished success to the forthcoming Conference of the Fédération Internationale d'Associations Nationales d'Ingenieurs, which is to take place early in September in Luxemburg.

The President then called upon those who had brought greetings to the meeting to give their addresses. Dipl.-Ing. Schuberth, the Bundes Minister for Post and Distant Communications, said that the Government recognised the ability of engineers to assist in problems of rebuilding. He felt that the control of natural forces and raw materials were in safe hands. Professor Dr. Mössner, the Minister of Trade and Transport, in the Niedersächsischen Landes Government, said that the industrialisation of the Hanover and Lower Saxony districts must continue if there was to be a solution of the refugee problem. The Government would support to the full the research necessary for this purpose. Dipl.-Ing Kuhlemann, vice-president of the Industry and Chamber of Commerce of Hanover, said that the close relations between the V.D.I. and Niedersächsischen industry, must continue. Finally, the Oberburgermeister of Hanover, Herr Weber, paid a warm tribute to the manner in which engineers had co-operated in reconstruction programmes in Hanover and district. He pointed out that for many many years the V.D.I. had been in close touch with the teaching and research bodies in Hanover.

The President then called upon Professor Dr. Deckert, Rector of the Hanover Technical High School, to deliver his lecture on "The Duties and Responsibilities of Engineers in the Modern World." After expressing warm greetings from the technical schools and the Technical High Schools, Dr. Deckert said that he did not intend to speak on those aspects of his subject, which had been dealt with in the Kassel and Marburg meetings already mentioned, but he would rather deal with some of the problems of the modern world. In his view it was not right to blame the engineer for any of the shortcomings of technical science, for it must always be borne in mind that the profession of the engineer only came into being with his work on the problems of science and industry. To-day it was necessary to look upon work as something bringing more than mere material gain. It should satisfy human aspirations for health, beauty, satisfaction with one's work, and leisure. How to preserve personal individuality in team work was, he thought, another important problem for solution. Tradition was very valuable, for it enshrined what had proved useful. But in rebuilding, despite tradition, there was danger in merely restoring that which had been destroyed. Development could not and should not be arrested. At the end of his address, Dr. Deckert quoted the words of the Psalmist: "Blessed is the man who, going through the vale of misery, makes in it a well." He liked to think of the engineer of the future as a man true to those words, one who found water in dry places and thus served his generation.

After the lecture had ended the orchestra played Bach's No. 3 Brandenburg Concerto.

The President then bestowed the honours awarded for 1951 by the Council of the V.D.I. The "Grashof Medal" was awarded to Professor Dr.-Ing. Wilhelm Nusselt, who for forty years in Dresden, Darmstadt, Karlsruhe and Munich, has lectured on thermodynamics and heat transmission, and has accomplished outstanding research work in those special fields. In conferring honorary membership upon Dr.-Ph. Dr.-Ing. Karl Wendt for his work for the steel industry in Essen, the President said he had occupied a leading position in the Krupp steel works and had served the V.D.I. in presidential office. The same honour was bestowed upon Professor Dr.-Ing. Carl Pfleiderer, of Brunswick, who, the President pointed out, had for nearly forty years been Professor of Engineering at the Technical High School, Brunswick. He had done outstanding work in fields covering centrifugal pumps and steam and water turbines, and for some time was chairman of the V.D.I. Committee for Centrifugal Pumps Rules. Honorary membership was also conferred upon President Dr.-Ing. Otto Konz, of Stuttgart, who designed and carried out the river works on the Neckar between Mannheim and Plochingen, and the canalisation of the River Neckar. He is a Vice-President of the V.D.I. and took a leading part in reforming the Wurtemburg Branch in 1947. The V.D.I. Mark of Honour was given to Herr Obering, Max Jungbluth, of Frankfort, the President citing that he had done much for the science of heating and had also taught the younger generation and helped the V.D.I.

The V.D.I. Ring, given to encourage young men under forty years of age, was conferred this year on three members. They were Dr.-Ing. Siegfried Schwaigerer, of the Stuttgart Technical High School, Materials Testing Department; Dr.-Ing. Johannes Kosmider, for his work on the production of basic steel by the Thomas process, with the Haspe Hüttenwerk, Hagen, and Dr.-Ing. Werner Stegemann, of the Ilo Werke Motor Works, Pinneberg, for his work on the air-cooling of multi-cylinder engines and the supercharging of aircraft engines.

The meeting closed with the playing by the orchestra of Wagner's Meistersinger Overture, after which the President thanked all who had contributed so much to make the Hanover meeting a memorable one.

On Wednesday evening, the Hanover Opera gave a V.D.I. Festival performance of Raimund's opera, "Der Alpenkönig and der Menschenfeind." There was also a public lecture on the making of technical films which was given on Thursday evening by Dr.-Ing. G. Wolf, of Göttingen.

On Tuesday and Thursday further sessions for the reading and discussion of papers were held in the Stadthalle. Among the papers presented the following may be mentioned, some of which are to be published in abstract form in the *V.D.I. Zeitung*:—

In the section devoted to power and heat, there were three papers, "Superheaters and Superheater Arrangement," by Dipl.-Ing. H. Erythropel, of Essen; "The Efficiency of Industrial Steam Turbines," by Dr.-Ing. K. Jaroscheck, of Hanover, and "Air-Cooled Condensers for Steam Turbine Installations," by Dipl.-Ing. C. Bayer, of Bochum. In the section on workshop practice, a paper was presented by Dr.-Ing. P. Leinweber, of Bremen, and Obering L. Hermann, of Stuttgart, on "The Measurement and Examination of Large Work Pieces"; Reg-Rat Dipl.-Ing. K. Meyer, of Bremen, dealt with "Problems of Hardness Measurement," and Dipl.-Ing. H. Mintrop with "Power Measurements." An interesting paper in the section on earth and material moving was that by Professor Dr.-Ing. H. Ernst, of Nuremburg, on "The Newest Crane Developments." In the machine tool section, Professor Dr.-Ing. O. Kienzle, of Hanover Technical High School, gave a paper on "Measurement and Determination of Powers and Output for Machine Tools"; Dr.-Ing. Dinglinger, of Bremen-Mahndorf, dealt with the "Boring of Deep Holes with Rotating Work," and Director K. Sieber, of Hamburg, described the saving to be effected by using cold forming methods. There was a special section devoted to building and civil engineering plant, and also one on district heating. Other sections included those devoted to planning for safety in the workshop, and manufacture and economics. On

Friday sessions dealing with heating and ventilating, and with food packaging, took place. Throughout the week visits were arranged to works and plants in Hanover and the surrounding district, and on the last day—Friday—a series of longer tours were arranged.

Among the firms to which visits were paid the following may be mentioned:—Dreyer Rosenkranz and Droop, of Hanover, measuring instruments; Gunther Wagner, Hanover, Pelikan inks and packing; Bähre Holzwerke G.m.b.H., Hanover; Hanomag, Hanover, tractors; Wohlenberg, Hanover, lathes and paper-cutting machines; Westinghouse, Hanover, brakes; the Technical High School, Hanover, machine tool and stamping and plate working research departments; North German Portland Cement firms; Würfel Engineering Works, Hanover, power transmission appliances; Hackethal Cable Works, Hanover; Garvens, Hanover, wagon works, and the Continental Rubber Works, Hanover. Opportunities were also given to visit the "Constructa" Exhibition and the Garden Exhibition in Hanover.

The whole-day visits arranged for Friday included two trips, one to the Maig Works, in Brunswick, and the other to the Iron and Steel Works of Ilsede-Peine, after which both parties visited the Reichwerke (formerly the Herman Göring Werke), in the Salzgitter district. Another visit was to the East Hanover power station, and the Lüneburger Heide, while a further party viewed the waterworks at Berkhof, and the firm of Wolff and Co., at Walsrode. Oil wells at Nienhagen owned by the Gewerkshaft Elwerath, were also visited, as also were the potash mines at Lehte, belonging to the firms of the Kalibergwerken und Wintershall A.G. Finally, a large party visited the Volkswagen, or People's Car Works, at Wolfsburg.

The Standard-Sunbury Engine Indicator "Mark 6"

By E. S. L. BEALE and R. STANSFIELD

No. II—(*Continued from page 217, August 17th*)

(3) *The Amplifier Controls.*—The amplifier is arranged so that the pick-up unit connections are made from the back, there being three sockets for this purpose. A fourth socket is connected in parallel with the third one with reversed polarity, so that two units can be coupled in parallel if required; the polarity can be changed if necessary at the amplifier if the pick-up is not easily accessible, or a second instrument, such as a maximum pressure monitor, can be used simultaneously with the indicator on the one pick-up.

In many applications it is necessary to use three similar pick-up units in three different parts of the engine, e.g., in different parts of the same cylinder or in separate cylinders. Unless the magnetic systems, the diaphragms, and the air gaps are identical, the scales of the three diagrams will be different. Means are therefore provided for the heights of the individual traces to be adjusted so that they are all to the same scale. These controls, which are situated at the bottom of the front panel of the display (or amplifier) unit, are recessed so that, once set, they are not easily disturbed by accident. They can also be used to adjust the relative scales of, say, cylinder pressure, spray valve lift, and fuel line pressure diagrams when the units for indicating these are in use together, to give diagrams which are of a convenient relative height. The main gain controls then affect all diagrams equally.

The main input gain control is continuously variable and is calibrated in terms of percentage of full gain from 0 to 100. There is also a "high-low" gain control recessed near the top of the panel, generally used in the low gain position, and to which reference will be made later. These apparent complications make the instrument much easier to use and permit pressures and displacements to be measured from the cathode ray tube face with reasonable accuracy. The unit used is selected by means of a three-position switch just above the gain control.

(4) *Integrated and Direct Diagrams.*—The value of the "direct" diagram from an electromagnetic unit, showing the rate of change of pressure or the velocity, has been abundantly proved. In its original form, however, it had two disadvantages: very high-frequency events often gave much too large a direct diagram from peak to peak, and the loading of the first stage of the amplifier was sometimes so great that subsequent distortion occurred. The relative size of direct and integrated diagrams has been improved so as to be better suited to average work. A change-over switch enables the integrating circuit with a suitable time constant to be chosen for either low or high-speed engine running without the use of an auxiliary switch. Change-over from one type of diagram to another is practically instantaneous without the float, which was sometimes so troublesome with the previous indicator. It should be added that

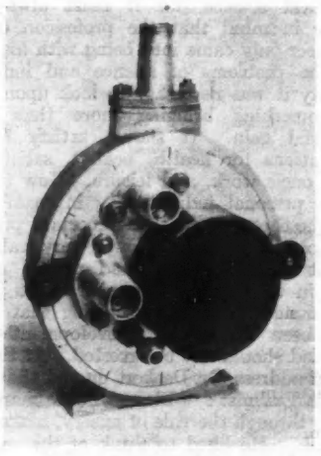


FIG. 8

all controls affecting diagram changes, such as the *X* and *Y* shifts, are direct-acting and operate without delay.

While accurate direct diagrams can be obtained when necessary up to high frequencies, it often happens that these show too many high-frequency waves of large amplitude to be readily usable. A high-frequency attenuator is therefore provided which gives a more readable diagram. H.F. attenuation is, however, rarely needed for the integrated diagram, and a third position of the switch, while still attenuating the direct input, gives a correct integrated diagram by restoring the high frequencies at the integrator. This is in marked contrast to the older instrument from which the integrated traces were always seriously attenuated as regards high frequencies, often just when these were most needed.

(5) *Time Base and Degree and Time Scales.*—The mechanical "time sweep unit" has been redesigned, and is now smaller, lighter, and gives better performance (Fig. 8). The arrangement is generally similar to the old one, consisting basically of a spindle running in ball bearings carrying a "degree wheel" to give a degree marking wave, and a cam to operate a contact breaker to control the start of the sweep of the time base. Improvements have been made in the mechanical design to give greater regularity in the operation of the contact breaker, and an additional pick-up is fitted on the phasing plate near to a magnetic projection on the degree wheel to generate a synchronising impulse. This, in conjunction with the new time base circuit, gives a very accurate and steady start to the sweep at all speeds down to about 450 r.p.m., or down to 180 r.p.m. if a 5 : 1 step-up transformer is used.

Provision is made for three different methods of triggering the time base. The first is the simplest possible one, as used in the old indicator, namely, short circuiting the time base condenser with the contact breaker, the sweep starting at the "break" of the contacts. The second method uses the same contact breaker to provide a triggering impulse to the thyratron-controlled time base. In this case the sweep is intitiated by the "make" of the contacts. The third method uses the impulse from the pick-up on the phasing plate applied to the thyratron time base. Alternatively, a pick-up mounted near a moving part of the engine can be used, such as a projection from the flywheel. In each of these three cases the time base normally makes a single stroke at each synchronising impulse, e.g., one stroke for each engine revolution. Alternatively, the time base can be set to "self-run"; it can then be synchronised by either contact or pick-up, or by a very small impulse which may be the signal on the screen itself when it is inconvenient to fit a synchronising device of any kind on the engine. A valuable improvement, the "divide-by two" feature, has also been introduced, which gives either the normal sweep once for each revolution of the engine with the two halves of a four-stroke cycle superimposed, or a sweep lasting two revolutions with either part of the cycle coming first, chosen as required by operating the time base select control. The value of this feature when studying pressure waves in manifolds, &c., or when examining torsiograms is obvious.

In addition to the degree marker giving 2 deg., 10 deg. and 90 deg. marks as before, time marking waves are provided to show 1 milli-sec and 10 milli-secs intervals. The required marker is selected by means of a three-position switch above the pick-up selector, and there is a separate gain control for adjusting the height of the marking waves independently of the pick-up gain control. A toggle switch is used to switch over from the indicator diagram to the degree or time marker. This is fitted in a convenient position on the left of the panel between the pick-up selector and the degree and time marker selector.

The scale of the time base is controlled as before with a "Velocity Coarse, *C*" and a "Velocity Fine, *R*" adjustment. The dials of these controls are calibrated so that the approximate sweep velocity can be read directly from them, the actual velocity in mm/milli-sec being given by multiplying together the scale readings on these two dials, $C \times R$. There is also a time base "frequency" control. This controls the repetition frequency in the self-run condition without altering the sweep velocity, so that the time scale can be kept constant, even when the engine speed is varying. This dial *F* is also calibrated so that the repetition frequency is given approximately in terms of r.p.m./1000 by multiplying together the readings of all three dials, $C \times R \times F$. The scale along the "*X*" axis is now practically linear, overcrowding at the end of the trace having been eliminated. The linearity and the velocity of the time base can easily be checked by means of the time marker. A push button is provided to enable the operation of the time base to be checked before a single-stroke experiment, to make sure that it is in proper adjustment.

(6) *Other Details.*—Terminals are provided on the left-hand side of the front panel for connecting auxiliary apparatus to the direct-

coupled output stage or *Y*-amplifier; it can thus be used for special work with other pre-amplifiers for different types of pick-up, or as a laboratory instrument. A Post Office type jack on the right-hand side gives access to the direct-coupled *X*-amplifier. Links are also provided at the back of the case giving access to the *X* and *Y* plates of the cathode ray tube. Two jacks at the back give a high impedance input connection (1 megohm) to the first stage for special purposes. Another two jacks at the back are connected in parallel with No. 1 input socket, one on each phase, for use with an unbalanced source such as a pick-up with one side earthed. In this way the diagram on the screen can be turned the right way uppermost whatever the polarity of the pick-up. Similarly, an additional balanced three-pin socket is connected in parallel with No. 3 input socket, but with reversed polarity.

There is a "modulate" terminal at the back to allow the intensity of the beam to be modulated by external means to provide time or position marks on the trace. There is also a socket at the back for injecting a position mark on to the diagram, such as the ignition point in a petrol engine. This circuit contains a limiter to give a square-topped mark and to prevent the marker circuit interfering with the signal circuit. Another socket allows the base line to be displaced vertically in accordance with, say, the backing pressure on the calibrating unit to facilitate taking calibrated pressure diagrams, &c.

A voltmeter is provided, together with a selecting switch, so that on the one hand the working conditions of the indicator, e.g., battery voltages, can be checked, and on the other hand, an adjustable calibrating voltage can be applied to the input to check the overall sensitivity, integrator constants, &c. The calibrating voltage is obtained for simplicity from the 50 c/s mains, when these are available, through a two-pin socket at the back and an isolating transformer, so that the socket can be plugged in either way round.

The viewing hood and its associated cursors have received special attention. The tube face bears against a bevelled, flat-fronted Perspex ring, which builds up the rounded edges so that tracing paper inserted in the hood fits snugly and without appreciable creasing; the tracing paper being readily fitted by lifting the hood, which is held by a quick-release catch. The two Perspex cursors are graduated in millimetres along each edge and there is a horizontal scale for reading their "*X*" adjustment. Two small shielded lamps in the upper corners of the hood give a controllable amount of light to illuminate the cursors and the tracing paper when the apparatus is used in a darkened room. The bottom edge of the hood is cut back to give convenient support to the hand when tracing.

Two sockets are provided at the top of the panel for fixing a tubular frame to support a black cloth, which is sometimes necessary when examining a trace at high writing speeds, when the general illumination is bright. Photographic records can be taken when required with a motor-driven continuous film camera connected to the amplifier by means of a special light-tight hood, which replaces the normal viewing hood. The same special hood can be used with most standard cameras when it is desired to take direct photographs of the screen traces and a simple adapter may be made to couple the camera to the hood to maintain the lens at the proper distance from the screen for accurate focusing.

Electrical Circuits

The chief features of the electrical circuits are, briefly, as follows:—

(1) *Signal Amplifier.*—The amplifying circuits are push-pull throughout and the signal is displayed on a standard 6in high-vacuum cathode ray tube. There are three stages of amplification, the second stage being used only when integrating, as in the old indicator. A simplified circuit diagram is shown in Fig. 9. The sensitivity has been increased to about ten times that of the old indicator; the overall gain of the three stages being about 200,000. With this high sensitivity every precaution must be taken against electrical noise, chiefly to avoid low-frequency float of the base-line on the screen. The sensitivity has in fact been taken to the limit set by electrical noise. The push-pull arrangement has many advantages. For example, it allows a much larger signal to be handled without distortion. Also, as the pick-ups and connecting leads are balanced to earth, there is much more freedom from hum pick-up from a.c. mains, which is sometimes very difficult to avoid with an unbalanced input. However, a pick-up with one side earthed can also be used when required and this is a detail which is a great improvement on the old indicator. These new input arrangements are made possible by a new method of applying the positive feedback, which is used to give accurate integration by eliminating the inherent errors of the elementary integrating circuit C_1R_1. The feedback circuit C_2R_2 is taken from each second stage anode to the first stage cathode of the opposite phase. The feedback works on exactly the same principle as before,† namely, by adding to the input signal to be integrated a voltage exactly equivalent to the back-voltage on the integrating condenser. The feedback adjustment is now pre-set to the correct value by an adjustment inside the case.

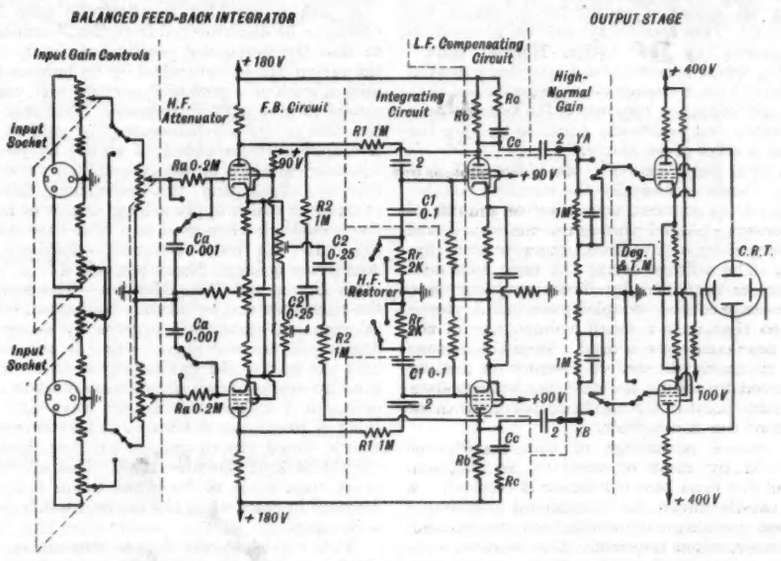


FIG. 9

Mention has already been made of the two-position gain control before the output stage, marked "High-Normal." In the "Normal" position this gives a reduction to one-quarter of the full gain, the maximum sensitivity being seldom required. This control reduces the electrical noise reaching the output from the first stage, where most of the noise always originates, and it therefore improves the steadiness of the base line, in particular during the warming-up period, just after switching on, before conditions have become stabilised.

The high-frequency attenuator and restorer circuit is of special interest. As already stated, this allows the high-frequency components in the input waveform to be attenuated to avoid the confusion often seen on the "direct" diagram from an electro-magnetic pick-up. The h.f. restorer then restores these components to their correct amplitude and phase in the integrated diagram, so that it is exactly the same as if no attenuation had taken place. The condition for this is very simple, namely, that the time-constant of the h.f. attenuator, C_aR_a, shall be equal to that of the h.f. restorer, C_1R_1. It is easy to show that if this condition is fulfilled the result is theoretically perfect. The value chosen for this time-constant is 200 micro-seconds. Apart from its use for clarifying the "direct" diagram, the h.f. attenuator has a very useful practical effect in reducing the unsteadiness of the integrated diagram when dealing with very peaky input waveforms. The reason for this unsteadiness is that, if the first stage does not amplify the positive parts of the input waveform to precisely the same extent as the negative parts, then the mean will no longer be zero. After integration this results in a change in the position of the base line of the diagram, which may vary from cycle to cycle. By reducing the amplitude of the high-frequency components, the "peakiness" is reduced so that the effect of any non-linearity in the first stage is greatly reduced. The push-pull arrangement of the first stage is also valuable in this respect.

(2) *Frequency Response.*—The frequency response of the system should be considered in relation to that required to give diagrams which are free from distortion and phasing error. The amplitude response should be constant over the whole significant frequency range from the lowest frequency contained in the waveform to be shown on the screen up to at least 10,000 c/s. At the low frequency end of the range phase errors are important, an error of a fraction of a degree of crank-angle being significant because of its effect on the work area of an indicator diagram. This applies only to pressure "indicating" units. With the "calibrating unit," which should always be used for accurate work-area measurements, the pulse output contains only high frequencies. At the high frequency end phase errors are important in their effect on the accuracy of the degree marker, an error here having the same effect as an error in the pressure diagram. For example, as the degree marker shows a wave on the screen of wave-length equal to 2 deg. of crank-angle, if the error is to be kept down to ¼ deg. of crank-angle the phase error at the frequency of the degree marker wave must be less than 45 deg. At an engine speed of 6000 r.p.m. this frequency is 18,000 c/s.

As already mentioned, frequency response of the latest design of electromagnetic pick-up units is free from significant error. In the case of the amplifier the integrated amplitude is correct within 1 per cent from about 2 to 5000 c/s. The amplitude response drops by about 4 per cent at 10,000 c/s. Except for the degree marker, where amplitude is of no consequence, higher frequencies than this are not important in engine indicating; however, at 30,000 c/s the amplitude drops by 40 per cent.

The phase error when switched to "Integrate, Low Speed" is less than $^1/_{10}$ deg. of angle at 3 c/s (180 per minute) and about ½ deg. at 2 c/s (120 per minute). When switched to "Integrate, Normal Speed," the same phase errors are obtained at about four times these frequencies. Thus, 500–600 r.p.m. is about the lowest speed at which "Normal Speed" switching should be used on a cylinder pressure

† Beale and Stansfield, THE ENGINEER, December, 1935. Brit. Specn. No. 453,887.

diagram. At high frequencies the phase error in the amplifier from the point where the degree and position markers are introduced is 25 deg. at 20,000 c/s (that of the complete three-stage integrating amplifier is only a little greater). This corresponds to an error of only $^1/_{10}$ deg. of crank angle on the degree marker at 6000 r.p.m. The required high-frequency response is obtained by cathode-to-cathode condensers between the push-pull pairs of valves, thereby reducing at high frequencies the negative feedback due to the individual cathode resistances. The very small phase error at low frequencies is obtained in the first place by the positive feed-back in the integrating circuit, as already described, and in the second place by the l.f. compensating circuits, C_cR_c, shunting the second stage anode resistances Rb. This is designed to correct for the phase advance due to the two interstage R–C couplings, each of which has a time constant of two seconds. These would otherwise give a total phase error of 6 deg. at 2 c/s.

The terminals marked Y_a and Y_b (on the front panel) give access to the direct-coupled output stage. The gain of the output stage is about 65, giving a sensitivity of 50mm per volt d.c. This sensitivity can be reduced to one-quarter by the "High Normal Gain" control, which consists of a 1 megohm potential divider. This is capacity-compensated, so that the high-frequency response is the same in both conditions and practically equal to that for the degree marker given above.

(3) *Time Base, &c.*—The time base or X-axis sweep circuit is basically the simplest possible in the circumstances, consisting of a bank of condensers charged through a resistance and discharged by a thyratron, giving a rapid fly-back. The voltage across the time base condensers is amplified by direct coupling to a single-stage cathode-coupled push-pull X-amplifier, so that only a small voltage rise in the time base condenser is used. Thus the voltage rise is nearly linear. Linearity is further improved by taking the charging voltage from a suitable point in the anode circuit of the other phase of the X-amplifier.

A special advantage of this circuit, not provided by most alternatives, is that one side of the time base condenser is earthed. In this way the sweep can be triggered by a simple earthed contact, short circuiting the time base condenser, when required. This is often convenient when indicating a single mechanical motion, as the motion of the part from rest can usually be made to break the circuit.

Reference has already been made to the new facility added to the basic time base circuit, namely, the divide-by-two circuit. This is a flip-flop arrangement of the simple Eccles-Jordan type using a double triode, which allows the time base to be triggered at every alternate synchronising impulse. Either of the two half-cycles of a four-stroke engine can be chosen at will by a switch which selects the output pulse from one or other side of the flip-flop circuit.

As is well known, this dividing circuit is rather sensitive to the shape of the impulse used to trip it. A pulse amplifier and shaper has therefore been added. This is arranged so that the time base can be triggered either from a mechanical contact maker, which is usually most convenient at slow speeds, or from a small electrical impulse. The latter is provided by an electro-magnetic pick-up fitted in the sweep unit close to a small projection of magnetic material on the degree wheel. It is particularly useful at high speeds, as it gives a very regular start to the sweep, being free from the variations inherent in a mechanical contact. In each case one side of the synchronising means, contact or pick-up, is earthed, which is sometimes essential. A positive-going pulse is required, so that to get the best results the pick-up should be connected so that the usual S-shaped output pulse first goes negative, giving a steep rise in the positive direction through zero.

The time base velocity is determined by two controls only, the "Velocity Coarse," which is a ten-position switch for the time base condenser, and the "Velocity Fine," which is the continuously variable charging resistance. The setting of these two controls determines the rate of voltage rise on the time base condenser. There is no gain control on the X-amplifier, so that sweep velocity is also determined. Any required sweep velocity can be obtained in this way. The start of the sweep should always be on the screen (or not far off it to the left), in engine indicating work, so as to minimise the effects of engine speed variation. This makes the X-amplifier gain control, often provided on oscilloscopes, unnecessary and undesirable.

The "T.B. Frequency" control allows the repetition frequency of the time base to be varied over a range of about 4 to 1 in its self-running condition without affecting the velocity. This is done by varying the negative bias on the thyratron, so as to vary the voltage to which the time base condenser rises before the thyratron fires, and fly-back occurs, thus varying the duration or spread of each trace. This control is useful for maintaining a constant length of diagram with an engine running at varying speeds, so that a given length on the X-axis always represents the same time interval.

A jack is provided to allow the time base circuit to be disconnected from the X-amplifier, so that the horizontal position of the spot on the screen can be controlled by an independent means, such as a potential varying with engine stroke to give a P–V diagram. This jack has contacts on it, which increase the gain of the X-amplifier (from about 16 to 60) by joining the two cathodes of the X-amplifier together, thereby eliminating the individual cathode resistances which apply a large degree of negative feed-back when used as a time base amplifier. In the more sensitive condition the sensitivity is about 20mm per volt d.c.

(4) *Degree and Time Markers.*—The scale of the time base can be directly calibrated, either in terms of crankshaft degrees by using the degree pick-up and degree wheel in the sweep unit (as in the old indicator), or in terms of time by means of two simple time markers, one giving a 1 millisecond timing wave and the other a 10 millisecond wave. These consist of simple tuned circuits which are impulsed by the fly-back of the time base. This allows an exact time scale to be given to an indicator diagram in cases when the degree marker is not applicable.

With regard to the degree marker, a very careful investigation has been made of the accuracy of this system and circuit changes have been made to eliminate practically all error in its indications. It has been found that the degree pick-up in conjunction with the degree wheel in the "sweep unit" is almost perfectly free from error when a suitable integrating resistance is connected across the pick-up. Great care has been taken with the amplifier to avoid introducing phase errors before reaching the C.R.T. screen. This has been done by connecting the degree pick-up through a 6 : 1 step-up transformer to the output stage of the Y-amplifier, which is specially phase-compensated at high frequencies. In this way the overall phasing error of the degree marker system is less than $^1/_{10}$ deg. of crank angle at 6000 r.p.m. An incidental advantage of this arrangement, which is most valuable in practice, is that, as the output stage is direct-coupled, the switching from the diagram from a pick-up to the degree marker (or time marker) is instantaneous with no float of the base line.

(5) *Y-Calibrating Circuit.*—A three-range calibrating circuit is provided for the Y-amplifier to enable the input voltage from the pick-ups to be measured. The circuit is operated from 50 c/s mains when these are available. It is simply a calibrated attenuator, with the voltage across it measured by the meter on the front of the panel and is arranged so as to apply at No. 1 input socket a known voltage, which can be adjusted to give a deflection on the screen equal to the signal to be measured. The voltage is then read directly from the meter and the setting of the attenuator. When measuring the input with amplifier switched to "Direct," it reads directly in millivolts peak-to-peak. When the amplifier is switched to "Integrate," a reading is given directly in microvolt-seconds by using the inner scale on the meter. (The integral of a 50 c/s sine wave of 1mV peak-to-peak amplitude is $10/\pi = 3{\cdot}18$ microvolt-seconds.)

(6) *Supplies.*—As already mentioned, the main supply for the indicator is taken from a 12V accumulator, so as to make the instrument usable in any situation, whether there is an a.c. mains supply or not. In the design of the circuits every effort has been made to keep the current consumption down to the minimum and, in spite of a greatly increased number of facilities, it has been reduced to less than 4A. The h.t. supply for the integrating amplifier is taken from a 180V h.t. battery and the current consumption from this has been reduced to 4mA. There are four 45V layer-type h.t. batteries of a kind which can be easily obtained. This type of battery is smaller and lighter than those previously used and has a much longer life.

The h.t. for the X and Y-amplifiers and the time base and the extra high tension for the cathode ray tube are supplied by a vibrator power supply unit. The e.h.t. is obtained by a voltage quadrupling circuit using metal rectifiers fed from the normal h.t. winding on the transformer. Thus there is no e.h.t. winding liable to break down.

In conclusion, the authors wish to thank the chairman of the Anglo-Iranian Oil Company, Ltd., for permission to publish the results of the work carried out at the Sunbury Research Station, where Messrs. Hulf and Morser made notable contributions to the development of the equipment. A special acknowledgment is due to Mr. Eastwood, of Messrs. British Electronic Industries, who built the prototype models of the indicator and was responsible for many improvements.

The Short SA/4 Jet Bomber

It has been announced that another four-engined jet bomber, the Short "SA/4," has successfully made its first flight. This machine, which is made by Short Bros. and Harland, Ltd., has four Rolls-Royce "Avon" jet turbines, vertically disposed in pairs on each wing. Details of the aircraft cannot be disclosed. It is hoped that both this machine and the Vickers "Valiant" four-engined bomber, which first flew earlier this month, will be demonstrated at the forthcoming S.B.A.C. flying display.

Jaw Crushers.—We are informed by Sir W. G. Armstrong Whitworth and Co. (Ironfounders), Ltd., of Close Works, Gateshead-on-Tyne, that it has recently acquired the sole rights to manufacture, in this country, "Kue Ken" jaw crushers, for crushing all classes of rocks and minerals. In these machines a direct-driven pump delivers a large volume of lubricating oil from a built-in reservoir to flood both the eccentric shaft and the toggle plates. The pump is fitted with a special control valve which automatically stops the power drive in the event of the oil level in the reservoir falling to the safety mark. A safety device built into the crusher flywheel also cuts out the power drive in the event of foreign matter, such as tramp iron, entering the crushing zone of the machine. This mechanism can easily be set to suit different requirements. In addition to jaw crushers a range of gyratory crushers is also being built, and these machines are fitted with similar safety mechanisms.

"Architectural Design Data for Solid Fuel."—A handbook with the above title has just been published by the Coal Utilisation Joint Council. It has been written by John Pinckheard, A.R.I.B.A., with the objects of providing architects with information on the storage of solid fuel in larger buildings and encouraging the incorporation of suitable facilities for delivery, storage and handling when new buildings are designed. The information given, while referring explicitly to buildings such as schools, hospitals and small factories, is valid for virtually all buildings with the exception of small houses. The book may be obtained from the Council at 3, Upper Belgrave Street, London, S.W.1, price 7s. 6d.

4-6-4 Locomotives for the Victorian Railways

WE have received from the North British Locomotive Company, Ltd., of Glasgow, particulars of seventy 4–6–4 locomotives under construction at its Hydepark Works for the Victorian Railways, Australia. These new locomotives, known as the "R" class, are to the design and requirements of Mr. A. C. Ahlston, chief mechanical engineer of the Victorian Railways, and inspection at the builders' works is being carried out by Mr. A. E. Turner and John Coates and Co., Ltd., of London. Although the engines are being built for the 5ft 3in gauge, it is of particular interest to note that provision has been made in their design for their conversion to a 4ft 8½in gauge. When such conversion is undertaken the main frames will remain unchanged, and the work will be simplified by the removal of distance pieces provided at the cylinder seatings to the frames, between the central connections of the cylinders, the tube plates is 16ft; there are thirty superheater flue tubes of 5½in outside diameter and 155 small tubes of 2in outside diameter. The smokebox tube plate, which is stayed above the tubes by braces to the first barrel ring, is attached to the boiler by a solid rolled angle ring and the outer firebox back plate is supported by longitudinal stays fixed to the third barrel ring.

The Belpaire firebox has an all-welded inner steel box with a long combustion chamber, and there are two thermic siphons, which support the brick arch. The roof stays are of "Longstrand" steel, with flexible stays fitted in the breaking zones and round the combustion chamber.

At the front of the firebox the boiler is supported by expansion shoes attached to the foundation ring and these shoes bear on slides fixed to the front end of the frame cradle

A "MBI" stoker unit supplied by the Standard Stoker Company, fitted to each locomotive, delivers coal under the firebox to a firing table in the centre rear of the box. The engine of this stoker is mounted under the floor

"R" Class Locomotive Particulars

Cylinders, diameter	21½in
Cylinders, stroke	28in
Wheels, coupled, diameter	6ft 0½in
Wheels, leading bogie, diameter	2ft 9in
Wheels, trailing bogie, diameter	3ft 1 7/8in
Wheels, tender bogie, diameter	3ft 2½in
Wheel base, coupled	12ft 10in
Wheel base, engine	36ft 3in
Wheel base, engine and tender	67ft
Heating surfaces:	
Tubes	1958 sq ft
Firebox, including siphons	285 sq ft
Total evaporative	2243 sq ft
Superheater	462 sq ft
Total	2705 sq ft
Grate area	42 sq ft
Boiler pressure	210 lb per sq in
Weight of engine in working order	107 tons 12 cwt
Weight of tender in working order	79 tons 16 cwt
Weight of engine and tender in working order	187 tons 8 cwt
Adhesive weight	58 tons 10 cwt
Adhesive factor at 85 per cent boiler pressure	4·04
Tractive effort at 85 per cent boiler pressure and 72in diameter wheel	32,080 lb

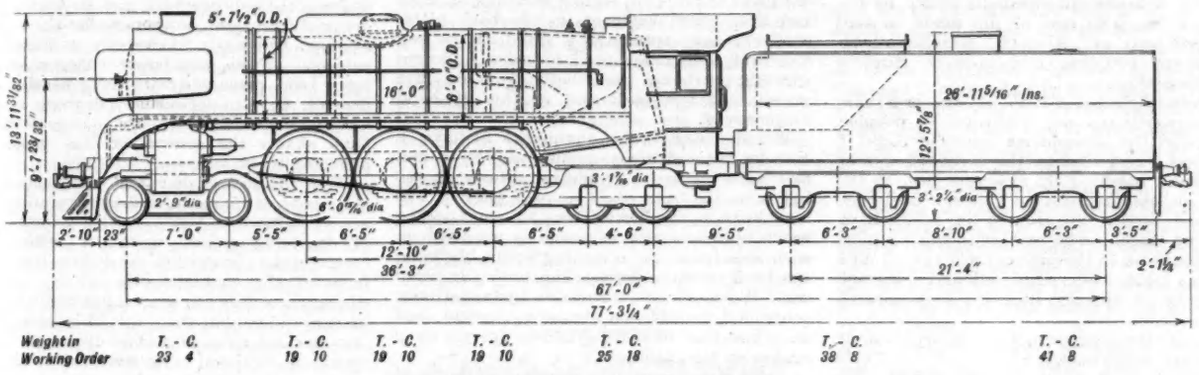


DIAGRAM OF 4-6-4 "R" CLASS LOCOMOTIVE

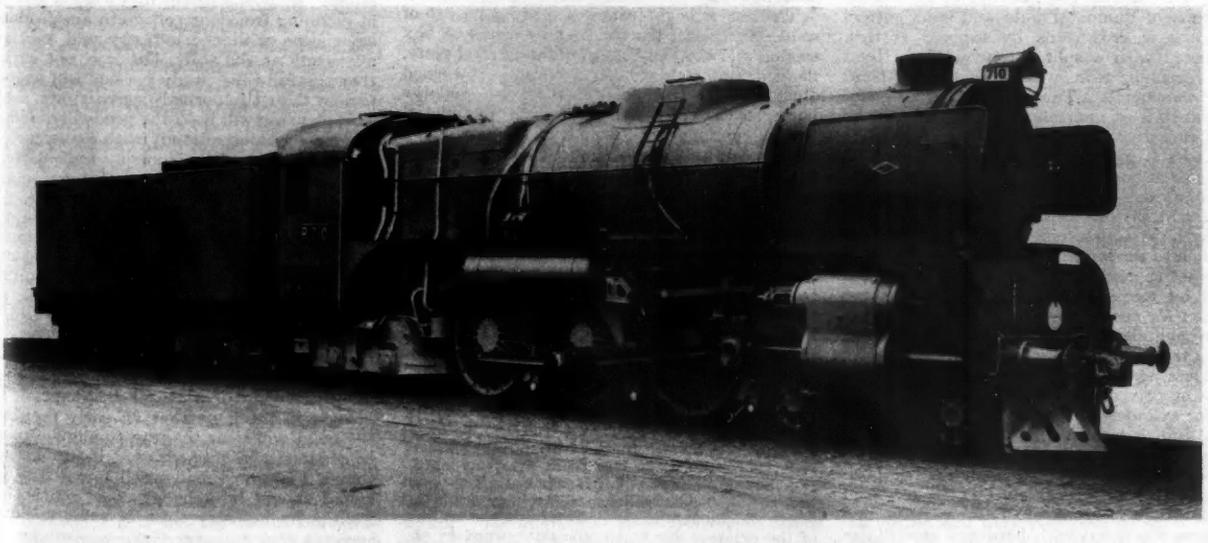
slide bar bracket and the trunnion and reversing shaft brackets.

The arrangement of the new engines and some of the leading dimensions can be seen in the photograph and diagram we reproduce on this page. Other leading particulars are given herewith.

In the boiler barrel, which consists of three rings with the middle ring tapered, the longitudinal seams are treble riveted, with the inside and outside butt strips and the circumferential seams double riveted. The distance between casting. To reduce bending stresses in the frames deflection plates are arranged at the front of each of the coupled wheels.

A cylindrical smokebox is fitted with a self-cleaning spark arrester, and attached to the cast iron chimney of the engine is a cast iron extension and a double mild steel petticoat. The balanced regulator valve is fitted with a pilot valve and there are two tangential steam driers fitted in the dome, steam being supplied through a 7in diameter internal steam pipe to a thirty-element "Melesco" superheater.

of the cab and it drives the feed screw in the trough through shafts, universal joints and a gearbox attached to the rear of the trough. The hand-operated "Waugh" fire grate, arranged for rocking and dumping in two sections, has fixed sections on each side of the stoker firing table. The fabricated ashpan, which is in two sections, is fitted with double hopper doors and provided with a drenching arrangement. Sliding doors on each hopper are operated by an air cylinder, and an air-operated Franklin fire door is actuated by a treadle on the platform.



4-6-4 "R" CLASS LOCOMOTIVE FOR VICTORIAN RAILWAYS

The general steam fittings of the locomotive include two "Nathan" 1918 non-lifting injectors, two "Coale" safety valves, one muffled and one plain, two blow-off cocks of Railways Department's standard pattern with separators fitted at front of firebox sides, two sets of water gauges with Klinger glasses, one water column and two pressure gauges.

The main frames are of the bar type, cut from rolled slab and finished to a thickness of 5in. A cast steel headstock, incorporating the buffer beam and dragbox, is securely attached to the front and the back ends of the frame. Ample staying is provided throughout the frames by cast steel cross stretchers. The frame horn shoes and wedges are of phosphor-bronze and the horn clips are of cast steel.

Compensation for the overhung coupled laminated bearing springs is arranged between the driving and trailing coupled wheels. Side buffers are fitted at front of engine and rear of tender and distance pieces are provided under the buffers to maintain the proper relation between buffers and couplers during the transition period. An "Alliance" automatic coupler is fitted into a pocket casting on the front engine headstock and a transition screw coupling is also provided. A drawbar and safety drawbar are fitted between engine and tender, together with an intermediate buffer of the wedge type. The rear of the tender is also equipped with an "Alliance" coupler, transition screw coupling and Spencer Moulton draught gear.

Grease lubricated S.K.F. self-aligning roller bearing axleboxes are fitted to all coupled axles, and the locomotives have "SCOA-P" cast steel wheel centres, the revolving masses only being balanced by means of lead in the wheel pockets. Tyres of the Victorian Railways' standard profile are secured in position by retaining rings. The crankpins and coupling rod pins fitted on the engines are forged from 3 per cent nickel steel, machined and hardened in accordance with the Railways Department's requirements.

The cast steel cylinders, which incorporate the smokebox saddle base, are fitted with renewable cast iron liners in the steam chest and cylinder barrels, and the cylinder and steam chest covers are also of cast iron. Each cylinder is provided with three release cocks, one for each end of the cylinder and one for the steam chest. These cocks are connected together by rods and actuated by an air cylinder and spring by a control valve situated in the cab. By-pass valves are also fitted at the bottom of each cylinder.

The locomotives have Walschaert's valve gear which actuates 11in diameter piston valves having a maximum travel of 6¼in and a cut-off at 75 per cent in full forward gear. Each piston has a 3½ per cent nickel steel forged centre with a cast iron bull ring riveted to its centre and fitted with two cast iron piston rings. The pistons are fastened to their rods by means of gunmetal nuts and split cotters and to their crossheads by tapered cotters, each fitted with a split safety cotter. Hand screw reversing gear is fitted on the left-hand side of the engine. The forged connecting and coupling rods of manganese-molybdenum steel are of fluted section. Adjustable brasses are fitted to the connecting-rods, whilst the solid coupling rod bushes are lined with white metal.

A six-feed "Nathan" lubricator for the valves and pistons is driven from the valve gear by links and levers, and from it oil feeds are taken to the steam pipes and to the top and bottom of the cylinders. All oil feeds are controlled by terminal checks and atomisers are provided for the feeds to the steam pipes and top of cylinders. The engine bogie centre, trailing truck pivot and coupled wheel axlebox horn faces are lubricated by a second six-feed lubricator driven in a similar manner to that used for cylinder lubrication.

The leading bogie frame is built up of steel bars with a cast steel transom and cast steel end bars cast integral with the outer horn cheeks. The inner cast steel horns are connected transversely by steel frame stays and the horns are fitted with hardened steel liners and tied by forged horn stays. Spring beams carrying the laminated bearing springs rest on top of the axleboxes and the bogie load is transmitted to the springs through seats attached to the underside of the side frame bars. The centring device consists of heart-shaped rockers having an initial and constant resistance of 33⅓ per cent. This bogie, which has roller bearing axleboxes, is attached to the main frame through a central pillar and its centre is fitted with mild steel and gunmetal liners.

The trailing bogie is of the four-wheeled "Delta" type and has an all-welded frame with hardened steel liners fitted to the horn openings, to which cast steel horn stays are applied. Laminated bearing springs are fitted and self-contained compensated spring gear is fitted between the bogie wheel springs. A cast steel pivot is attached to the top of the leading end of the frame and a phosphor-bronze lubricated liner is provided between the pivot seat and the pivot casting on the engine frame. As with the other wheels of the locomotive, Skefko roller bearing axleboxes are fitted. The bogie centring device consists of heart-shaped rockers having a constant resistance of 20 per cent.

The locomotive cab is of riveted construction and it has a ventilator in the roof, a door in the right-hand front plate, hinged windows in the left-hand front plate, sliding windows on sides and drop panel windows on the back plate. Staff exchange apparatus is fitted on the cab side and a Flaman speed recorder is driven through gearboxes and shafts from an arm studded to the back end of the left-hand coupling rod.

Westinghouse brake equipment includes a 10in by 10½in single-stage air compressor, and two 13in diameter cylinders actuate brake blocks on the front of all coupled wheels. The hind bogie is fitted with two 8in short-stroke brake cylinders, one of which is mounted on each side frame for operating brake blocks at the back of the wheels. The tender is fitted with Westinghouse automatic hydrostatically controlled, variable-load brake equipment, and on it two 10in diameter cylinders operate clasp brakes on all wheels.

Each of the cast iron sandboxes, mounted on top of the boiler, and arranged to deliver sand to the front of the leading coupled wheels, is fitted with an air-operated sand trap controlled by a valve in the cab. Electric lighting equipment provided for both engine and tender includes a headlight with a focusing device, two electric marker lamps on the smokebox front, two electric marker lamps and one back-up lamp on the rear of the tender tank, cab and gauge lamps.

The double four-wheeled bogie tender takes 9000 gallons of water and 6 tons of coal. Its tank and bunker are of welded construction, but angles for stays and wash plates are riveted to the tank. The tender underframe of mild steel plates and sections is of welded construction throughout to form an integral unit.

The tender bogie frames and transoms are of mild steel plate, flanged and welded into box section and the end bars are of mild steel plate, flanged and welded into position. Hardened steel liners are provided at the horns and the horn stays are steel castings. Laminated bearing springs with equalising beams fitted above each axlebox are housed within the side frames, and a cast steel bolster is suspended from the transoms by means of swing links and trunnions. A cast steel bogie centre plate is bolted to a seating on the bolster and provided with a wearing plate. Mild steel case-hardened rubbing plates are attached to the mating faces of the bolster and the transoms and to the seats on the top of the bolster. The clasp brakes on the tender can be operated by hand as well as through the Westinghouse brake equipment.

FIRST TANKER AT FAWLEY.—The first tanker to berth at the marine terminal of the new Fawley refinery of the Esso Petroleum Company, Ltd., was the "Esso Fawley," of 14,500 tons. The vessel brought 4,000,000 gallons of Arabian crude oil which will be used in the first stages in the working of the refinery, due to be officially opened by the Prime Minister on September 14th.

The Technical College*

By H. J. CULL

HIGHER technological education has become almost a popular debating subject in all scientific and educational circles in recent years. In technical colleges it has for a long time been a matter of real concern and urgency.

Probably this subject was first crystallised by the report of the Percy Committee in 1945. The experience of many industries during two world wars had made it abundantly clear how dependent they were upon those with sound scientific and technological training. The Percy Committee's review of the demand for trained technologists and the shortages which were likely to arise has been emphasised by the many and varied reports which have been published since.

But it could rightly be claimed that the whole question of higher technological work in technical colleges is a natural part of the development of these institutions. In practically all the major departments of the colleges there have evolved courses for Ordinary and Higher National Certificates—awards which have suited the part-time nature of the studies of the students and the close association with the needs of industry. Side by side with these courses, the colleges have met an ever-popular demand for classes to prepare for the external London University degree in a number of subjects. From the larger colleges students have been presented for the general science degrees, the special science degrees and the various engineering degrees. Recent reports have shown the growth of this work and, incidentally, its success.

With the picture, however, ever before us of the needs of industry, colleges feel that they are more fitted to press on with a further step of development and design a technological course of the standard of the degree, but having more of the characteristics of the technical education of this country embedded in it. The need would be that there should be more of the fundamental basis of science included than is usual in National Certificate and Diploma courses and that the applied science and technological side should receive much more recognition than is to be found in the external degree syllabuses. The colleges are not looking to provide an easy alternative to the degree, but they do feel that if the liaison with industry is to be maintained and developed they can provide courses which, with the freedom of an internal examining system (with suitable safeguards) could well be different from the external degree.

This provision of the new courses of "first degree" standard raises several problems which must be solved if the programme is to proceed. First, it is contemplated that, having at the lower levels proved his ability, the student shall have freedom for periods of full-time study. Indeed, schemes may vary a great deal in planning from one college to another and in association with one industry and another at all events at the start, but it is not expected that the full-time study periods will aggregate to less than the normal degree study periods. This planning will need the goodwill of industry if the association of study with experience is to be a vital part of the course. Indications and experience do not suggest this as a major problem.

Secondly, there is the vexed question of the award to be received by the successful student. It is not the intention here to retrace the much-trampled paths on this subject. It cannot be denied that rapid success for the scheme could only be expected if the award were one with national recognition and backing. Those who have advocated a degree award will join, however, with those who have accepted the scheme of membership of a Royal Institute of Technology, in the hope that an early decision on the point will clear the way to allow courses to be planned and started. Let it just be added that if hopes are really well founded the new award should be a badge of so much that is wanted by industry that its value could soon

* British Association, Edinburgh, August 13th.

be established. The one regret would come to all of us interested if the colleges were able only to award their own diplomas, which, however high they might rise in local esteem, would carry little value to a student who desired to change his area of employment—a loss to the student and surely to industry.

Given the opportunity for these schemes to be developed, the problems of post-graduate training are not so formidable. Some colleges already run courses of an advanced and specialist nature, and many of these would continue, but be made more valuable as more men were equipped with the requisite basic training to benefit from following such courses. Many of these classes it is certain, could be developed jointly with university neighbours.

Two associated problems should be dealt with before saying more on post-graduate studies. Colleges are in need of general expansion and much good work is hampered even now as a consequence. However, local authorities and the Government are showing signs that as far as possible technical education is to expand. Local organisation changes, too, are being tried to liberate space for advanced work. It could be claimed that this increased accommodation is not just desirable, but essential. All authorities concerned and the Government will then need to be as willing as some authorities now are to see that the provided accommodation shell is fitted with suitable equipment and apparatus. It is, of course, to be expected that such supplies will be an expensive item, but we are facing a problem which will, if solved, bring high dividends to the community as a whole.

The associated problem is one of staff. The added space of itself demands an increase. But size of staff is only one side of the question. As always, it is balanced by the question of quality. The planning here suggested calls for some of the best available manpower with suitable scientific and/or technical experience. Not only will many need academic equipment, but very real experience of industry and its needs. In the past it has meant definite financial sacrifice for such men to join college staffs, but some have done so. In England and Wales the recent Burnham report has given scope, it is thought, if properly used, for such appointments to be made. It may well prove that there are gaps still to be filled, but at any rate the measure of freedom now offered is new and its effect will be watched with interest.

If it could be found possible to solve these two problems of accommodation and staff, then one development in post-graduate work which would change the whole prospect would be possible—the gradual establishment of centres of research. Research is not new to technical colleges. Many individual staff members have persevered with their research even under great inconvenience. In a few cases research has been done in a department by students, supervised by the head of department. These students, however, have usually done the work on part-time, probably evening, basis. Recently, however, the conditions have been extended. The Ministry of Education has approved a reduction in the teaching hours of members of the staff engaged on research. Then, too, there are authorities who have agreed to the appointment of research assistants. Conditions of appointment of these latter vary from place to place, but there are already cases where such people have qualified for higher university degrees. As such centres develop it should be possible to bring into being teams of research workers, including staff and students. In some problems it may even be an advantage if some of those workers are on a part-time basis from industry. Most here will know university conditions and will appreciate the value to any senior institution that must accrue from the presence in the department of such investigation work. Many of the problems subject to investigation might conceivably come from industry itself, and in the same way as many industrial corporations find themselves bordering on pure science research, some college investigations might well be direct industrial problems, though not, it is hoped, with too much emphasis on the time element.

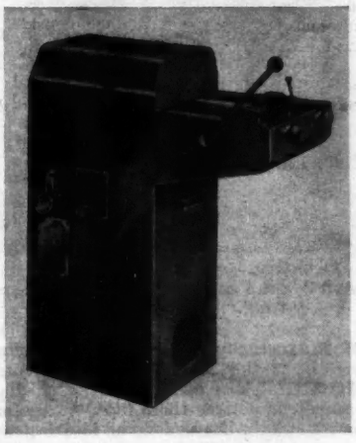
Now, in having treated this subject from the college angle, it has been essential to look at a problem which we hope is in the state of "being solved" and to talk of practical difficulties. There are others to which only passing reference can be made. Not every technical college could or should be called on for such higher technological courses. It will be essential to view such needs on a regional basis, and such is in large measure being done at the present time. The question of such co-operation may well be claimed to be receiving adequate consideration by the various regional advisory councils and the corresponding national council. However, if the aim and scope of these colleges really attain the level hoped for, it may be that the basis of financial responsibility as between rates and taxes will need consideration. No more need be said save to mention the matter as probably needing consideration, since finances as between central and local authorities appear due for examination. Just let it be added that, in the same way as the educational needs appear to need local direction, so in college government the local representation would appear of essential importance.

In closing this brief review of college position let us turn from details for a moment and return to the main theme. The colleges realise the problem of the shortage of trained men for industry. They know that part of their function is to provide the trained "technician." But they know, too, that the experience they have gained has qualified them to go beyond this and build courses of which the foundations are laid and help to provide the technologist required by the country as a whole. In doing this they believe they can give the student much of the fundamental work that the external degree demands, but can mix with this the studies which give the technological adaptability desired. There is in the colleges at the moment the enthusiasm to do this work once it is given direction and the student the necessary incentive.

A Single-Spindle Screwing Machine

A RECENT addition to the products of Chamberlain Industries, Ltd., of Staffa Road, Leyton, London, is the "Staffa" ⅜in single-spindle screwing machine, illustrated below. This compact, self-contained machine is intended for the accurate high-speed threading of bolts, pipes and small components.

The fabricated pedestal of the machine com-



⅜IN SCREWING MACHINE

prises two side panels, pressed out from mild steel sheets, which form an integral part of the cutting lubricant and swarf cradle. Small angle sections within the pedestal provide support for the side panels, the motor, cutting lubricant reservoir, and bearing housing platforms. At the front and rear removable panels give access to the interior.

The hollow spindle, upon which a rotating die head can be fitted, runs in self-lubricating "Oilite" bearings and thrust washers of the same material take the end loads during cutting. A small gear pump within the reservoir pumps the cutting lubricant on to the work through the hollow spindle. The flow of oil washes swarf from the die head and keeps both sides of the chasers clean. The spindle and lubricant flow control fittings are totally enclosed at the top of the machine by a removable push-on cover, and the die head itself is enclosed by a hinged cover. Mounted directly under the mouth of the cutting lubricant and swarf cradle is a removable swarf trough, fitted with a fine wire mesh gauge filter.

The carriage assembly comprises a flat-top table, on which any form of self-centring vice or work-holding fixture can be mounted. Two tubular guide bars, running the length of the cradle which provide the carriage slide bed, are extended on either side of the front bearing housing to maintain the correct alignment of the table top. The forward and return movement of the carriage assembly over its 9in of travel is controlled through simple links by the action of a lever swinging through an arc of 90 deg.

The length of thread cut is set by two screwed shafts fitted with trip-adjusting nuts and housed in the tubular slide bars. A crosshead bracket inside the machine's pedestal couples two ends of the screwed shafts together, and from this crosshead bracket the yoke of the die head is automatically controlled. The two trip-adjusting nuts on the screwed shafts are positioned on either side of the carriage table and are adjusted inside the slide bars by means of two control knobs at the front end of the cradle. These knobs are graduated to indicate the length of table movement. The forward and return action of the carriage registering against the trip nuts ensures automatic opening and closing of the die head. In case of emergency the operator can open the die head by pressing the control knobs at the front end of the cradle.

The spindle is driven through a single vee belt and a variable speed gear unit by a ¾ h.p. motor. The range of speeds available is 266 to 1007 and is obtained by adjusting a quadrant operated by a control handle at the side of the machine. A pointer indicates on a graduated scale the speed at which the die head is running.

Metalclad Oil Switch Units

Two new designs of oil switch made by Crompton Parkinson, Ltd., Chelmsford, are shown in the illustrations overleaf. The first switch (Figs. 1 and 2) is a feeder isolator, known as type "A.S.A.1"; the second (Fig. 3) is a ring main unit, known as type "A.R.A.2." Both equipments are suitable for service voltages of 6·6kV or 11kV, continuous load current 400A. They are designed for load breaking and making on to a fault of up to 250MVA, and have a short-time thermal rating of 250MVA for three seconds.

The oil switch isolator is metalclad for indoor service, with air insulated single busbars. It lines up with the company's "A.L.A." metalclad oil circuit breaker switchgear (as shown in Fig. 1) the frame dimensions being such that it can be fitted in any position and changed for an oil circuit breaker unit when required.

An external handle on the front of the unit operates copper blade contacts, which engage rounded multiple copper strip contacts, slotted to ensure even alignment (as shown in Fig. 2). The moving blades are reversible to give double life and the fixed contacts are easily renewable. An innovation in the design of the oil switch is that the blades open inwards and not outwards, so that the electromagnetic loop under short circuit conditions tends to close instead of open the switch.

There are earthing contacts at the rear of the oil switch and they are operated by a separate handle on the front of the unit. A braided flexible lead connects the copper strip moving

blades to the earthed case. The fixed contacts are of the same design and rating as the main isolating switch contacts. The main and feeder earthing switches are interlocked by two sliding gates at the front of the unit, arranged so that only either the main switch or the earthing switch can be closed at any one time. An additional interlock can be provided between the earthing switch and the cover at the top of the unit protecting the testing sockets. The oil switch tank can be raised and lowered by a built-in winch gear operated from the front by a removable handle. Two "A.S.A.1" isolators, used for the control of ring main feeders, provide the maximum flexibility of switchboard construction, in that any number of oil circuit breaker units, &c., can be included between the two ring main units.

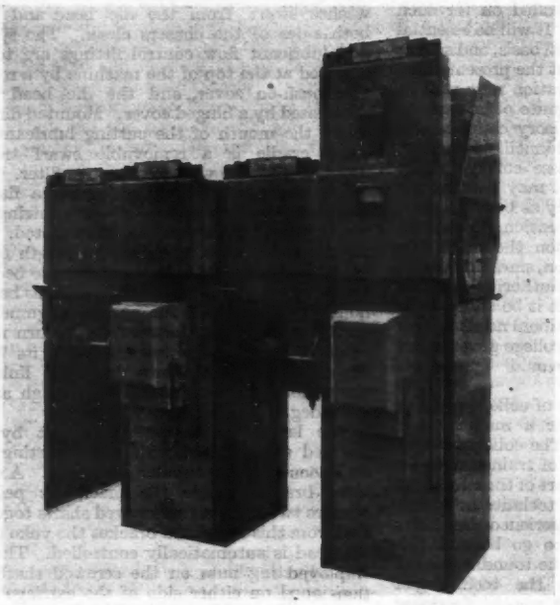


FIG. 1—"A.S.A.1." FEEDER ISOLATOR UNITS WITH "A.L.A." SWITCHGEAR

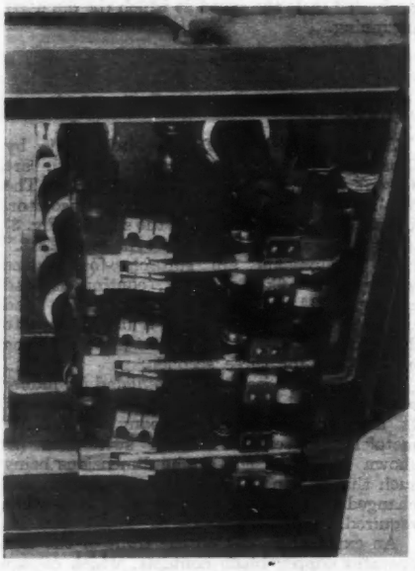


FIG. 2—"A.S.A.1." SWITCH CONTACT ASSEMBLY

The "A.R.A.2." ring main unit, which is metalclad for outdoor or indoor service, incorporates two sets of three-phase isolator and earthing contacts for controlling an outgoing and incoming ring main. It is a compact unit with complete interlocking and contact design similar to that of the "A.S.A.1." unit. The "A.R.A.2." unit can be directly connected to a Crompton Parkinson "T.A.P." automatic fuse oil circuit breaker (shown in Fig. 3), to provide an economical switchgear assembly for controlling high voltage single-line feeders for rural substations, large consumers' supplies, &c.

The "T.A.P." circuit breaker has been designed for the control of small current circuits at high voltage up to a maximum of 500kVA, or within the rating of the standard fuses. At these ratings it is technically superior, as a circuit-breaking device, to an oil switch with current transformer operated releases in the speed of disconnection on the occurrence of a fault. It is not intended to provide close over-current protection, nor is this necessary in any of its usual applications. The fuses incorporated were developed in the high power testing station of Crompton Parkinson, Ltd., and are available for a range of load currents and for proved breaking capacities of 100MVA, 150MVA and 250MVA.

We learn that, during the series of tests carried out on the "A.S.A.1." oil switch in the company's testing station, the unit, which is rated for an r.m.s. symmetrical short-circuit current of 21·9kA, with a peak making current of 55·9kA, actually made an r.m.s. symmetrical current of 22·4kA, with a peak making current of 64·3kA. The earthing switch, which has the same contacts as those fitted to the main isolating switch, has undergone identical tests.

FIG. 3—"A.R.A.2." RING MAIN UNIT WITH "T.A.P." CIRCUIT BREAKER

BULK BITUMEN INSTALLATION.—The second of three bulk bitumen installations, which form part of the Shell Petroleum Company's programme to supplement bitumen supplies in Europe, was recently opened at Setubal, south of Lisbon, by the Portuguese Minister of Economy. The plant has a capacity of 6000 tons and "hot" bitumen, at about 130 deg. Cent., will be brought direct to Setubal from the Caribbean in three converted Shell tankers. Special road tank wagons equipped with heating arrangements deliver the bitumen ready for spraying to the site of the road operations.

French Engineering News

(From our French Correspondent)

The National Centre of Scientific Research, which is an official organisation and which concentrates on scientific research in all fields, is to open an inventions office. This office, it is stated, will be separate from the Patents Office, although its work will be similar in some respects. The new Inventions Office will not only examine inventions by outside engineers, but will also grant subsidies to enable the engineers to develop their ideas. Naturally, any invention passed by this office will receive a patent certificate automatically from the Patents Office.

* * *

Algerian electricity production is causing some concern. First of all, costs are extremely high, and while this is considered normal in a country which lacks water power, prevailing opinion insists that too little thought has been given to the electrification plan for the country. In the first place, there are over twenty hydro-electric plants producing less than 150 million kWh annually. There are eight thermal plants which produce almost nothing, and altogether hydraulic, thermal and diesel plants produced no more than 366 million kWh in 1949, compared with 413 million kWh produced by the Electricité de Strasbourg alone.

Because Algerian plants are relatively small production costs are high. In France small groups average between 50,000kW and 100,000kW, whereas in Algeria they are below 25,000kW. The cost price in Algeria, therefore, is about 100,000 francs per installed kilowatt against between 50,000 and 70,000 francs in France. The critics point out that the cost of labour in the two countries is almost the same. On this basis the cost of an Algerian plant is about double that of a French plant. Coal consumption by the thermal plants is also uneconomical when compared with France. New plant being installed at Oran and Bone are expected to reduce this discrepancy.

Since hydraulic power on a large scale is almost impossible, the concentration of thermal plants is considered essential. This, however, introduces distribution problems. In Algeria consumption is about 40kWh per hectare against, for example, 200,000kWh in the Paris region.

* * *

The Société Agglorex has announced that it will shortly put into service a "travelling plant" for the agglomeration of coal and coke dust. Previously the pits have had to send their very fine coal and dust to special plants to be turned into bricks. The cost of transport has played a large part in the selling price.

The plant comprises a platform mounted on pneumatic tyres. It is equipped with a vertical boiler which provides steam for the mixer. When the mixer is full the necessary quantity of pitch is added and the mixing starts. The mixture is then carried by an endless belt to a 3-ton press at the other end of the trailer to be pressed into bricks. The installation includes tar crushing machinery which is driven, along with the other machinery, by a 65 h.p. Latill tractor, which also hauls the trailer. This travelling plant started work on July 30th, and is said to be the only one of its kind in France.

* * *

The Syndicate of Rolling Stock Constructors has asked that a definite construction programme be established by the Ministry of Transport and the S.N.C.F. In a published statement the Syndicate complains of the slowness of railway reorganisation. It says that this delay is holding up the preparation of a construction programme which both the S.N.C.F. and the Ministry consider of the greatest importance. In contradiction of reports from some quarters that the railways actually have more trucks than they can use, the Syndicate says that many of the trucks are over age and that a replacement programme is necessary. The report draws attention to the programme of O.E.E.C., whereby railway networks in all the countries will have to be up to strength as far as rolling stock is concerned. France is well below this level at the moment.

Industrial and Labour Notes

Steel Control

The Ministry of Supply has announced that control over the distribution of the main descriptions of carbon steel is to be reintroduced on December 3rd. The existing arrangements for controlling the distribution of sheet steel, tinplate, terneplate and blackplate will remain unaltered.

The new arrangements for control will be similar to those which operated up to May, 1950. As from December 3rd, no person will be permitted to acquire carbon steel wthout an "I.S. authorisation." The authorisations will be issued to firms to acquire specific quantities of steel for specific purposes, and they will also allow firms' sub-contractors to purchase steel to fulfil sub-contracts. These arrangements, however, will not apply to building and civil engineering firms, which will receive notice from the Ministry of Works telling them how to apply for the steel they need.

Any steel-using firm, except a sub-contractor, which will be requiring carbon steel and has not had an authorisation before, should make application early in September as follows:—If more than 25 tons of steel a quarter are required, the firm should apply to the Government Department which it normally contacts on matters of production; if 25 tons or less a quarter (including not more than 10 tons of sheet) are used, the firm should apply to the Ministry of Supply Regional Controller. In cases of doubt, application should be made to the Ministry of Supply, Iron and Steel Division, Shell-Mex House, Strand, London, W.C.2.

I.S. authorisations will not be needed to buy small quantities of carbon steel (1 ton a quarter or less, according to the description of steel). Full details of these exemptions for small quantities are to be issued later. Iron and steel stockholders will again need licences to acquire controlled descriptions of steel for resale. Stockholders who had licences during the previous period of control will be told direct what action to take, but iron and steel stockholders established since May, 1950, should write for a licence to the Ministry of Supply, Iron and Steel Division, Shell-Mex House, Strand, London, W.C.2.

The T.U.C. Annual Report

The annual report of the General Council of the Trades Union Congress has been issued this week. It will be presented to the eighty-third congress, which opens at Blackpool on September 3rd.

As usual, the report is a document of considerable size, and in its 434 paragraphs covers the principal activities during the past year of the General Council and its standing committees. The paragraphs dealing with the deliberations of the T.U.C. economic committee are, naturally, of particular interest. Summing them up, the report says that in the present economic situation trade unions must endeavour to maintain the real wages of their members by demanding wage increases. Some favourably placed sections, it is stated, may be able to to achieve that, but it is not likely to be possible for workers as a whole. With rearmament and export demands increasing, a fall in standards of living could only be avoided by a considerable increase in production. To say that production may be jeopardised by shortages of raw materials and conversion to rearmament projects, the report observes, is not to deny, but rather to emphasise, the need for both sides of industry to co-operate fully in increasing the efficient use of the available resources and in eliminating wasteful methods. Trade unionists, it is claimed, have a wealth of experience to offer in achieving those objects, "and it is essential that they shall—and shall be allowed to—play their full part."

At the same time, the report points out that "the developing rearmament programme will, in the immediate future at any rate, mean a fall in the standard of living of the community as a whole," a matter which raises new problems in the search for "a policy which will ensure a fair distribution of the burden." The efforts of unions to raise wages, the T.U.C. says, cannot alone prevent a reduction in the standard of living, "although they may mitigate it to a greater or less degree." It is suggested that every effort ought to be exerted by the Government to establish as soon as possible a new and more stable level of prices.

The T.U.C. Agenda

The agenda for this year's Trades Union Congress contains eighty-nine resolutions from constituent unions, compared with seventy-six last year. They are classified in nine sections, one of which is headed "Industrial Policy and Organisation." One resolution in this group, from the Electrical Power Engineers' Association, notes with concern "that continued load shedding and the progressive curtailment of essential electricity supplies to industry are inevitable for a long period to come unless the allocation of capital to the nation's electrical system is increased."

Another resolution—from the National Union of Vehicle Builders—says that "many workers in the nationalised industries are beginning to have second thoughts on the character of the nationalisation carried through. They see little change in the make-up on the boards and on the administration side the same faces as of old." The resolution calls for a drastic reduction in compensation payments; vastly improved wages and conditions, and a change in the composition of the nationalised boards with increased representation from the workers and technicians.

Engineering Wages

As briefly recorded in our last issue, the Confederation of Shipbuilding and Engineering Unions debated a number of resolutions on wages at its annual conference at Swansea last week. As a result, the Executive Council of the Confederation was instructed to present a claim immediately for a wage increase of £1 a week for all adult workers in the engineering, shipbuilding and ship-repairing industries.

The principal resolution on the matter came from the Amalgamated Engineering Union, following the recent annual meeting of its national committee. The four main points of this resolution were: an increase of £1 per forty-four-hour week for all manual workers employed in the engineering and shipbuilding industries; the new consolidated rate to form the basis for calculating all piecework and bonus earnings; all piecework prices to be such as will enable every workman to earn at least 33⅓ per cent on the consolidated time rate, and all merit rates and craft and district differentials to be maintained.

The last general wage increase in the engineering industries, it will be recalled, came into effect last November. As the result of an agreement between the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions, skilled men received an increase of about 11s. a week, and unskilled men 8s., to bring their weekly remuneration to £6 8s. 2d. and £5 6s. respectively. Piecework prices or times were adjusted where necessary so that an average worker could be enabled to earn at least 45 per cent on the existing basic time rates instead of 27½ per cent as hitherto.

Britain's Overseas Trade

Figures issued by the Board of Trade last week give the value of exports of United Kingdom goods in July as £222,200,000, which was 7 per cent above the average for the first six months of this year, but about £8,000,000 below the record values achieved in April and May. Imports during July continued at the high level of recent months and have been estimated at £358,900,000, thus bringing the total value of imports in the first seven months of this year to £2,215,300,000. With re-exports in July valued at £9,600,000, the excess of imports (valued c.i.f.) over total exports (valued f.o.b.) during the first seven months was £679,300,000.

Employment and Unemployment

The Ministry of Labour's latest statistics on the employment situation in Great Britain show that, at the end of June, the total working population numbered 23,324,000 (15,949,000 men and 7,375,000 women). The increase recorded during June was 35,000 (11,000 men and 24,000 women).

The number of people in civil employment at the end of June was 22,301,000, or 43,000 more than at the end of May. Of that total, 4,172,000 were working in the basic industries, to the labour forces of which there was a net addition of 19,000 during the month. The greater part of that addition was accounted for by the seasonal increase in the number employed in agriculture. In coal mining, there was a decline of 1000 in the number employed, the total of wage earners on colliery books at the end of June being 701,000. In the manufacturing industries, 8,676,000 people were employed at the end of June, or 11,000 fewer than at the end of May. The labour force of the metals, engineering and vehicles trades decreased by 9000 during June, a circumstance which must be attributed to the materials shortage. In the building and contracting industries, there was an addition in June of 15,000 to the number employed, and there was also an increase of 15,000 in the number of people engaged in professional, financial and miscellaneous services.

Reporting on unemployment, the Ministry of Labour says that on July 16th there were 185,847 people registered as out of work, compared with 190,776 a month earlier. The July figure, it is stated, represented 0·9 per cent of the total working population. The Ministry has estimated that, in the week ended June 30th, about 35,000 operatives in the manufacturing industries were on short time, losing twelve hours each on the average; on the other hand, 1,254,000 people were working, on an average, eight hours' overtime.

A Report on Manpower

The monthly review of the economic situation, entitled *Bulletin for Industry*, which is prepared by the Treasury, has made an analysis of this country's manpower situation up to the end of May. From it, four conclusions have been reached, as follows:—The number in civil employment continues to rise slowly, but steadily; unemployment is at its lowest point since 1945, and short-time working is negligible; particular labour shortages of great importance exist in the coal mines and on the railways, and for skilled men in the defence programme, and release of labour, where it is not fully employed, can help to meet urgent defence and export orders. In May, the survey says, there was generally a severe shortage of labour. There were no signs of releases of large numbers of workers from manufacturing industries as a result of shortages in supplies, and there was a growing shortage of labour, both skilled and semi-skilled, in areas of concentrated industry, particularly engineering.

It is clear, the survey continues, that the demands of rearmament will have to be met by a rearrangement of the labour force rather than an increase. At present, vacancies on defence work are being filled largely by internal transfers of workers, but, it is emphasised, substantial releases from less important production must occur if the defence programme is to be carried out. It is suggested that there was less redundancy during June than in previous months, but reports indicate that there was some short-time working.

Notes and Memoranda

Rail and Road

BRITISH TRANSPORT CHARGES SCHEMES.—The Minister of Transport has granted the application of the British Transport Commission, under Section 76 of the Transport Act, for a further period of two years from August 6, 1951, for the preparation and submission to the Transport Tribunal of the Commission's draft charges schemes. The Commission has already submitted to the Tribunal a draft national passenger charges scheme. The further period of two years is likely to be required for the draft dock charges scheme. In the case of the draft merchandise charges scheme, time is needed for further discussions between the Commission and coastal shipping interests. The Commission has, however, informed the Minister that this draft scheme will be ready for submission to the Tribunal within a few months.

TRANSPORT TRIBUNAL.—The Minister of Transport has appointed August 15, 1951, as the date on which the jurisdiction of the Road and Rail Appeal Tribunal was transferred to the Transport Tribunal. The president of the Transport Tribunal has appointed Mr. N. L. C. Macaskie, K.C., Mr. E. S. Shrapnell-Smith, C.B.E., F.C.S., M.Inst.T., M.I.Chem.E., and Captain B. H. Peter, C.B.E., A.M.I.E.E., to hear appeals formerly heard by the Road and Rail Appeal Tribunal. Mr. Macaskie will act as president for the hearing and determination of the proceedings. Communications which would have been addressed to the Road and Rail Appeal Tribunal should now be sent instead to the Secretary, Transport Tribunal, Watergate House, 15, York Buildings, Adelphi, London, W.C.2. The office of the Appeal Tribunal at 6, Spring Gardens, London, S.W.1, will become a sub-office of the Transport Tribunal.

Air and Water

PERUVIAN GUNBOATS.—The new river gunboats "Ucayali" and "Maranon," which were built by John I. Thornycroft and Co., Ltd., for the Peruvian Navy, have sailed on their 6000 miles' voyage to Iquitos after undergoing repairs for damage received during the first attempt to sail to Peru.

H.M. SURVEY SHIP "SCOTT."—H.M. Survey Ship "Scott" will be at Antwerp from to-day, August 24th, until August 27th, and be open for inspection by the delegates to the International Union of Geodesy and Geophysics Conference. This opened in Brussels on August 21st and will close on September 1st. Among the delegates is the Hydrographer to the Navy, Rear-Admiral Archibald Day.

AIRCRAFT TORPEDO RANGE.—The limitations of the present aircraft torpedo range for the testing of modern weapons have prompted the Admiralty to find a new site which will satisfy technical requirements, and 5 square miles of sea off the south-west Cornish coast, near the Manacles, has been selected. Local amenities will not be affected, as no power diving or low flying is required, and there will be no noticeable increase in the number of aircraft. The constructional work consists of two observation posts, the adaptation of an existing jetty and some stores buildings. Navigation in the estuary will not be restricted and the "clear range" procedure will be used in the dropping area, so that the free use of coastal waters is safeguarded. A local inquiry will be held before the use of the area by the Admiralty is approved.

Miscellanea

ELECTRICAL ASSOCIATION FOR WOMEN.—The twenty-seventh annual conference of the Electrical Association for Women will be held in Scarborough from Monday, May 19, to Saturday, May 24, 1952.

ILLUMINATING ENGINEERING SOCIETY REGISTER OF LIGHTING ENGINEERS.—The first annual issue of the Register of Lighting Engineers has recently been published by the Illuminating Engineering Society. Anyone requiring the services of a qualified lighting engineer may obtain a copy of the register on application to the I.E.S., 32, Victoria Street, London, S.W.1.

BRITISH POWER TRANSFORMERS FOR CANADA.—The Aluminum Company of Canada has placed a contract with Ferranti, Ltd., Hollinwood, Lancashire, for power transformers totalling 400,000kVA to operate at 300kV and 275kV. They are to be installed at the new hydro-electric stations, Kemano and Kitimat, in British Columbia, and are believed to be the highest voltage power transformers yet ordered in the United Kingdom.

CONNAH'S QUAY GENERATING STATION.—The British Electricity Authority has applied to the Minister of Transport for his consent under the Coast Protection Act, 1949, to the construction of intake and outfall works below high-water mark of the River Dee at Connah's Quay, Flintshire. Plans illustrating the proposed works may be inspected at the office of the Clerk of the Connah's Quay Urban District Council, Connah's Quay. Representations or objections regarding this application should be made to the Secretary, Ministry of Transport, Berkeley Square House, London, W.1.

SULPHUR AND SULPHURIC ACID PRODUCTION.—At the Stanlow refinery of the Shell Petroleum Company, Ltd., the plant is being modified to provide the maximum amount of sulphur during the period of shortage. When built the plant was part of a long-term plan to convert the hydrogen sulphide produced when cracking hydro-carbons, to elemental sulphur, which in turn was to be used to provide the sulphuric acid required in the refining of oils. The sulphur recovery plant will produce 10,000 tons per annum and will commence operations at the end of this year, while the acid plant, which will take in 5000 tons of sulphur per annum and convert waste sulphuric acid sludge to fresh acid, will not be commissioned until late in 1952.

NICKEL BANS POSTPONED.—The Ministry of Supply and Board of Trade announce that, following representations by industries affected by the Nickel (Prohibited Uses) Orders, it has been decided that the date from which the nickel plating of articles listed in the second schedules to the Orders will be prohibited, shall be October 1st instead of August 22nd. It has also been decided that the disposal of articles containing controlled material, or which are nickel plated, shall be permitted without licence up to December 31, 1951. Under the present Orders disposal was prohibited after October 1st and August 22nd respectively. These changes have been made to allow manufacturers more time to turn over to alternative methods of production and to dispose of existing stocks.

POWER STATION CONSENTS.—The British Electricity Authority has received the consents of the Minister of Fuel and Power to the establishment of the proposed new power station at Marchwood, near Southampton, and to the extension of the Goldington power station at Bedford. The Marchwood station, which will stand on a site of approximately 140 acres, will have a capacity of 480MW, comprising eight 60MW turbo-alternators and eight boilers, each having an evaporative capacity of 550,000 lb of steam per hour. The extension of the Goldington station comprises four 30MW turbo-alternator sets, four boiler units, each of an evaporative capacity of 300,000 lb of steam an hour, and three cooling towers. The first two turbo-alternator sets and associated boilers of this station have already been authorised.

THE WORLD METALLURGICAL CONGRESS.—Preparations are now being completed for a World Metallurgical Congress, which is to be held in Detroit from October 14th to 19th. The arrangements are primarily in the charge of the American Society of Metals, which is organising a series of study tours of industrial centres prior to the Congress meetings. These tours will begin on September 13th and will, for the most part, take place in the north-eastern area of the U.S.A. Visits will be made to steelmaking and refining plants, non-ferrous manufacturing concerns, metal fabrication works, heat-treatment and welding establishments, inspection and testing departments, and to engineering and metallurgical educational and research establishments. Representatives from twenty-one countries are expected to take part in the tours and attend the Congress.

INSTITUTE OF PHYSICS.—The Board of the Institute of Physics announces the establishment of an examination by which those not holding a recognised university degree may satisfy the academic requirements for election to graduateship and, subsequently, when the necessary approved experience has been acquired, for the acquisition of professional status as a physicist by transfer to the corporate grade of associate of the Institute. Candidates for the examination will normally be required to have followed a suitable course of study at a college or other institution recognised for this purpose by the Institute. The subjects of the examination are physics (three papers and a practical examination), mathematics (two papers), and a third subject (one paper) chosen by the candidate from applied physics, more advanced physics, mathematical physics, and statistics. Those choosing applied physics will be required to offer only one of the sections, viz., electronics, high-vacuum technology, acoustics, spectroscopy, X-rays, or temperature measurement. Direct election to graduateship without examination will be still open to holders of recognised university degrees in physics. Certain other degrees or other qualifications, such as the Higher National Certificate in Applied Physics, will entitle the holders to exemption from up to four of the six papers of the examination. The first examination will be held in 1952. Copies of a booklet containing the full regulations and syllabuses of the graduateship examination may be obtained free, on request, from the Institute of Physics, 47, Belgrave Square, London, S.W.1.

REGISTRATION OF VEHICLES.—On August 15 the Ministry of Transport made effective the Road Vehicles (Registration and Licensing) Regulations, 1951 (S.I. 1951, No. 1381), and the Road Vehicles (Index Marks) Regulations, 1951 (S.I. 1951, No. 1380), which together will replace the existing registration, licensing and seating regulations. There is now special provision for the exhibition of registration marks on works trucks, which are defined as vehicles designed for use in private premises and used on roads only in passing to various parts of the same premises or to other private premises in the immediate neighbourhood. Their registration marks may be exhibited on both sides or only on the back of the vehicle, instead of on both front and back, and need no longer be illuminated at night. The registration marks of pedestrian-controlled vehicles may be of the smaller dimensions already permitted for motor bicycles.

Personal and Business

E. H. JONES (MACHINE TOOLS), Ltd., has recently doubled the floor area of its sales offices at 10, Dover Street, London, W.1.

RICHARD SUTCLIFFE, Ltd., Horbury, Wakefield, states that Mr. H. Streets, formerly chief technical engineer, has been appointed technical director.

MR. PETER WRIGHTSON, deputy managing director of Head Wrightson and Co., Ltd., Thornaby-on-Tees, has been elected to the North-Eastern district board of Martins Bank, Ltd.

THE ASSOCIATED PULP AND PAPER MILLS, Ltd., Melbourne, has appointed Messrs. Hitchins, Jervis and Partners, consulting engineers, for a new pulp and paper mill at Geelong, Australia.

DR. EDWARD U. CONDON has resigned his position as director of the National Bureau of Standards, Washington, D.C., to become director of research and development of the Corning Glass Company, Corning, N.Y.

MR. J. JONES, whose retirement from the position of chief engineer of the National Gas and Oil Engine Company, Ltd., Ashton-under-Lyne, was announced in our last issue, will continue to act as director and general manager of the firm.

MR. J. F. ELPHICK, A.M.I.E.E., M.Amer.I.E.E., until recently Power Adviser, Land Nordrhein-Westfalen, under the Foreign Office (German Section), has been appointed overseas liaison engineer on the staff of the British Electricity Authority.

MR. MISHA BLACK, F.S.I.A., director of Design Research Unit, Ltd., has been appointed to advise the British Overseas Airways Corporation on the design of the equipment which will be housed in the central maintenance base now being constructed at London Airport.

LONDON AND OVERSEAS FREIGHTERS, Ltd., announces that Mr. W. E. Loveridge, who retires shortly from the post of engineering director of Richardsons Westgarth and Co., Ltd., has been appointed to the board and will act as technical consultant and adviser.

LONDON TRANSPORT announces the following appointments:—Mr. A. R. Purves, A.M.I.Mech.E., engineering superintendent (road services), and Mr. T. C. Ball, A.M.I.Mech.E., plant engineer (buses and coaches), in the department of the chief mechanical engineer (road services); Mr. A. C. Edrich, A.M.I.C.E., permanent way engineer (railways), in the department of the chief engineer.

HARLAND AND WOLFF, Ltd., announces that Mr. I. C. Green, who has been manager of the Finnieston diesel engine works, Glasgow, for many years, has retired for reasons of health and has been succeeded by Mr. Ernest F. Souchotte, from the company's Belfast works. The firm also states that Mr. W. C. Crawford has, for reasons of health, retired from the managership of the Scotstoun Works, Glasgow, and has been succeeded by Mr. Frederick H. Duncan, who has been assistant manager for a number of years.

British Patent Specifications

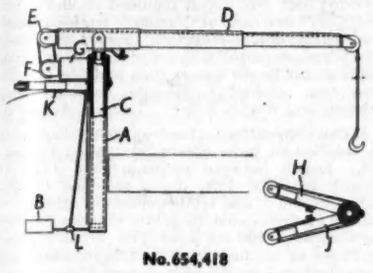
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

CRANES AND LIFTING APPLIANCES

654,418. February 25, 1948.—Portable Hydraulic Cranes, Eric Olov Sundin, 11–13, Vawsgatan, Hudiksvall, Sweden.

This invention relates to hydraulic hoists or derrick cranes and more particularly to a portable crane on a wheeled vehicle or on a boat or lighter. The drawing shows the arrangement of the hoist. *A* is the vertical pressure cylinder and *B* the hydraulic pump. The piston *C* is rotatable in the cylinder and has at its upper end a bifurcated block between the arms of which the crane lever *D*, is pivotally mounted. The longer arm of the crane lever carries at its outer end a pulley for a line, which at its free end is provided with a hook. The shorter arm carries at its outer end a pulley holder for a number of grooved pulleys *E*, over which and over a corresponding number of pulleys *F* on the



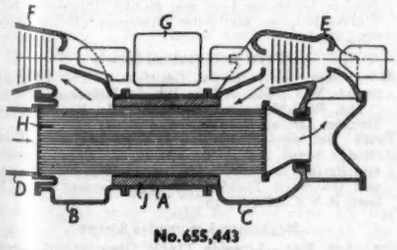
No. 654,418

lower pulley holder *G*, the line is passed. The piston cylinders *H* and *J* for turning the crane lever in a horizontal plane are arranged in V form and both of them are securely attached to the vertical pressure cylinder at *G*. Each of the pistons has at its outer end a grooved pulley wheel for a line. These lines are at one end fastened to the pulley holder *F* and at their other end to a stationary part *K* of the load vehicle. When fluid from the pump is forced into one or the other of the piston cylinders *H* and *J*, the pulley holder *F* is turned. A regulating valve *L* is so arranged that the supply of the pressure fluid may be regulated to and from the vertical cylinder and the piston cylinders for moving the crane lever in a horizontal plane. The longer arm of the crane lever is telescopic so that before loading or unloading it may, for instance, be drawn out to its full length by hand or hydraulic power.—*June* 20, 1951.

GAS TURBINES

655,443. October 13, 1948.—Gas Turbine Power Plant, The Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 13, St. Paul's Churchyard, London, E.C.4 (*Inventor: Karl Baumann*).

According to the invention, in a gas turbine power plant, a gas reheater is provided in which the gases from the combustion chamber, before entry into the high-pressure turbine, are used to reheat the same gases exhausting from this turbine and before entry for further expansion in a lower-pressure turbine. As shown in the drawing, the gas reheater comprises a casing built up in three sections, a cylindrical middle section *A* and two bulbous



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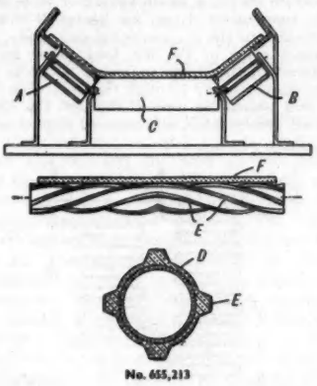
end sections *B* and *C* secured to the middle section to form a unitary structure to which the combustion gases are directed from a combustion chamber discharge conduit *D*. The casing is made sufficiently robust to form a support for mounting a high-pressure turbine *E* on its upper surface at one end and a low-pressure turbine *F* at its other end. The high-pressure turbine may be coupled with the load and the low-pressure turbine to an air compressor *G*. Centrally mounted within the lower half of the reheater casing is a cylindrical nest of heat exchange elements comprising a number of spaced tubes *H*, through which the combustion gases are directed. To ensure more intimate contact of the exhausting gases with the tubes in the interior of the nest a cylindrical layer of insulating material *J* is arranged in the middle section. The gas flow is indicated by the arrows.—*July* 18, 1951.

MINING ENGINEERING

655,213. August 9, 1948.—Idlers for Belt Conveyors, The Sutcliffe Moulded Rubber Company, Ltd., Ashbrook House, Church Street, Ossett, Yorkshire; Thomas Desmond Sutcliffe and Albert Glover, of the said company's address.

According to the invention the cover of at least one roller of a belt conveyor has on its outer surface ribs or bars. The ribbed rollers cause the belt to vibrate as it passes, first on one side and then on the other to settle the load on the belt and decrease in spillage. A ribbed roller can also be mounted near a point at which material is loaded on to a



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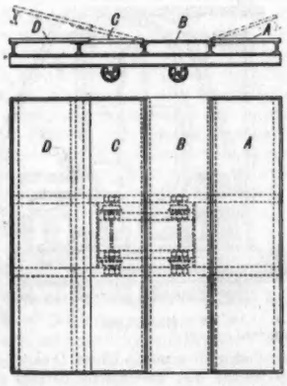
belt, for the purpose of counteracting the tendency of the load to move the "off" side of the belt, and impair the alignment of the belt. In the drawings the conveyor section shown comprises two wing rollers *A* and *B* and a central roller *C*, each provided with a rubber cover *D* having longitudinal ribs *E*, the belt *F* passing over these covers. The mounting of the rollers is shown diagrammatically. As can be seen from the lower part of the drawing, which shows the return run of the belt, the ribs are arranged in helical formation, the helices being spaced apart from one another.—*July* 11, 1951.

655,059. March 10, 1948.—A Portable Ripping Platform for Mining, John Edward Caine, No. 26, Chapel Avenue, Brampton, Wombwell, near Barnsley, Yorkshire; Clifford Beaumont, No. 16, Cliffe Road, Brampton, Wombwell, near Barnsley, Yorkshire.

Referring to the drawings, the ripping platform has five loose H-section steel girders laid across the main girders, and four steel sheets *A*, *B*, *C* and *D* are mounted on the girders. Sheets *C* and *D* are bolted together to form a single sheet. Sheets *A* and *C* are hinged to a pair of girders, and sheet *B*



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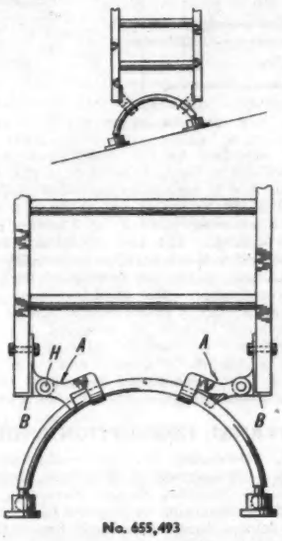
can be secured at both edges or simply laid in position between the sheets *A* and *C*. The outside edges of sheets *A*, *C* and *D* are raised slightly. The platform is used in the following manner. The loose girders are positioned across the chassis and the sheets bolted on top. The platform is then wheeled under the ripping, raised slightly off the rails and wooden blocks placed under it. The ripping is then blown or dropped on to the platform. The sheet *A* and the outside girder are tilted as shown in dotted lines in the upper view, with the aid of a lifting jack to place the ripping debris on to the sheet *B*. Sheets *D* and *C*, which are bolted together, are also tilted to place the debris on the sheet *B*. The whole platform and its girders can be lifted with the aid of a jack placed under one of the chassis girders to deliver the debris at either end of the sheet on to a conveyor, which delivers the debris into packholes. By placing the sheets crosswise on the girders the sheets and platform can be tilted to deliver the debris on to the gate belt.—*July* 11, 1951.

CIVIL ENGINEERING

655,493. June 21, 1948.—Support Units for Ladders Used on Uneven or Sloping Ground, John George Hanington, 31–39, Duncan Road, Gillingham, Kent.

The ladder support unit consists of a semi-circular tube each end of which carries a foot. The feet are joined to the support tube by ball and socket



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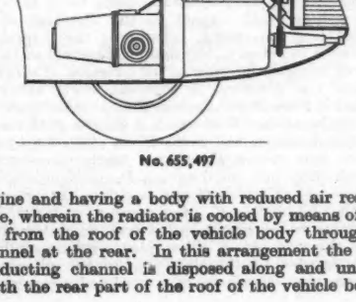
joints. The foot of the ladder rests on, and is supported clear of, the ground by the semi-circular tube by a gripping device *A*, comprising a pair of spaced lugs pivotally mounted on the bottom of each side pole by a bracket *B*. The bracket is adapted to carry the gripping device for pivotal movement in the plane of the ladder as shown. The support unit can be quickly and easily attached to an ordinary ladder.—*July* 25, 1951.

AUTOMOBILE ENGINEERING

655,497. June 28, 1948.—Radiators in Motor Vehicles Provided with Rear Engines, Arthur Abbey, 111–112, Hatton Garden, London, E.C.1. *Communicated by Tatra narodni podnik, of Koprivnice, Morava (CSR), Czecho-Slovakia.*

This invention relates to an arrangement of the radiator in a motor vehicle provided with a rear


No. 655,497

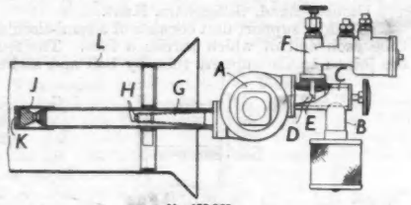
engine and having a body with reduced air resistance, wherein the radiator is cooled by means of air led from the roof of the vehicle body through a channel at the rear. In this arrangement the air-conducting channel is disposed along and underneath the rear part of the roof of the vehicle body,

the outlet opening being situated in the rear end wall and serving for mounting the radiator. In order to ensure that with such a radiator arrangement, the engine remains readily accessible, there is provided in the top wall of the body an opening which is closed by a hinged cover body confining the air channel from the top, as shown in the drawing.—*July* 25, 1951.

BURNERS AND SPRAYERS

655,282. June 21, 1948.—APPARATUS FOR BURNING LIQUID FUELS, Christopher Shorrock, of Moorlands, Garstang Road, Preston, Lancashire.

In the drawing, which is a diagrammatic side view of the apparatus in partial section, a compressor *A* of some 3 cubic feet per minute capacity is driven by a ½ h.p. electric motor. An air inlet conduit *B* to the compressor is controlled at its inlet end by a rotary valve *C* giving a wide variation of inlet cross-sectional area. Near the end of the



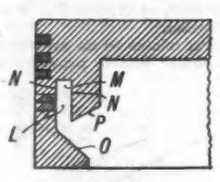
No. 655,282

conduit attached to the compressor there is a narrowed part or Venturi throat *D*, so that the speed of the air flow is materially increased at this point. Fuel oil is led to the throat through a jet *E* by way of a metering valve *F*, as described in Specification 655,281. The fuel oil admitted through the jet or orifice *E* is immediately partially atomised and entrained in the air flowing at high velocity to the compressor. The discharge from the compressor is through a frusto-conical nozzle *G*, which has discharge orifices *H* arranged to impart a turbulence to the fuel/air mixture as it passes through a conduit to a swirl cone *J* and burner nozzle *K*. A conventional secondary air tube *L* is shown surrounding the conduit.—*July* 18, 1951.

INTERNAL COMBUSTION ENGINES

655,324. December 22, 1947.—MOVING LIQUID FOR LUBRICATION OF INTERNAL COMBUSTION ENGINE PISTONS, Societe Nationale D'Etude et de Construction de Moteurs D'Aviation, 150, Boulevard Haussmann, Paris, France (*Raymond Marchal and Olivier Durouchoux*).

This invention relates to means for moving liquids through members effecting alternating periodic displacements. It is applicable particularly, but not exclusively, for moving lubricating oil in compressor or internal combustion engine pistons. It lowers the oil consumption of an engine by



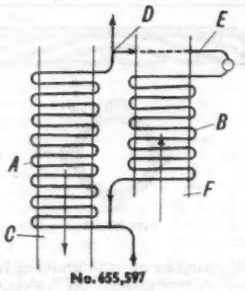
No. 655,324

improving efficiency of oil scraping piston rings. Referring to the upper drawing, a liquid moves in a passage *A—B* comprising successive recesses separated by partitions the upper faces of which are oblique with respect to the direction of the alternating movement. Assuming that liquid has gathered in recess *C*, the main component of inertia forces being at the time in the direction of arrow *D*. When the direction is reversed along arrow *E*, liquid is forced out of recess *C* and strikes partition *F*, the lower face *G* of which is oblique with respect to the direction of inertia force. The liquid thus flows into recess *H*. Upon further reversal of inertia force into the direction *D*, the liquid likewise moves out of recess *H* and is driven into recess *J* by the oblique face *K*. As a result of such elemental movements of liquid, a general displacement in the direction *A—B* takes place, substantially at right angles to the direction of the alternating movement. Members of a modified cross section are also shown. The lower view shows a cross section of a piston body with oil scraping rings and a passage bored in the piston body for receiving the scraped oil, which passage communicates with the groove of the piston wherein the scraper rings are located. One side of the passage *L* is formed inside the piston by a recess *M* having parallel walls *N* extending in the direction of the alternating movement of the piston, and on the other side it is provided with an oblique wall or surface *O* opposite to the recess, the wall *O* constituting with another oblique wall *P* an inwardly flaring aperture opening into the piston body. In this application the recess *M* plays a part analogous to that of one of the recesses shown in the upper view. By such an arrangement it is possible to provide for a continuous removal through the piston of oil scraped by rings.—*July* 18, 1951.

HEAT EXCHANGERS

655,597. October 4, 1948.—AIR HEATERS, Senior Economisers, Ltd., 11, Southampton Row, London, W.C.2, and Lewis Empsall Hardy, of the company's address.

The drawing shows part of an air heater system embodying the invention. For the heating of the combustion air for a steam generator incorporating a heat economiser *A*, an air heater *B* similar in construction to the economiser is provided. In the air heater some of the hot feed water from the economiser of the steam generator which is heated by flue gases passing through the duct *C*, is tapped at *D* and passed by pipe *E* through the elements of the air heater, while air is caused to pass laterally



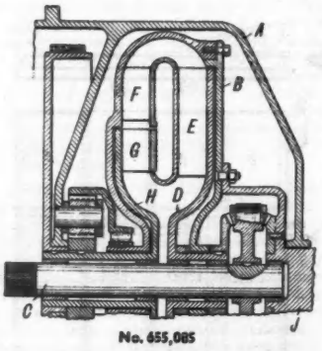
No. 655,597

in relation to the air heater through a duct *F*. The air is conveyed to the combustion chamber after being heated by the hot water and passed through the air heater elements of the air heater. In alternative arrangements shown in the specification, all the feed water from the economiser is caused to pass through the elements of the air heater. Should the temperature of the air leaving the heater not be high enough, then the temperature can be raised still further by passing it through a conventional air heater arranged in the gas stream between the economiser and the boiler, or, alternatively, between the banks of tubes in the economiser.—*July* 25, 1951.

HYDRAULIC ENGINEERING

655,085. February 26, 1948.—HYDRAULIC VARIABLE-SPEED POWER TRANSMISSION, Jarvis Carter Marble, Armstrong Lane, Riverside, State of Connecticut, U.S.A.

The transmission shown comprises a non-rotating housing *A* within which is the rotatably mounted converter casing *B*. A central power input shaft *C*



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has journalled on it a pump wheel *D* carrying a ring of pump blades *E*. The casing carries a ring of turbine blades *F*, these blades being shaped and arranged to cause the casing to rotate in the same direction as the pump wheel (which will be considered as forward rotation) when the working liquid is circulated by the pump. A second ring of turbine blades *G* is carried by a turbine wheel *H*, the shaft portion of which is in the form of a sleeve journalled on the input shaft *C*. The blades *G* are arranged to receive the discharge from blades *E* and are shaped and arranged to cause the wheel *H* to rotate in the opposite or reverse direction with respect to the pump wheel when the working fluid is circulated and whenever conditions are such that the wheel *H* acts as a power transmitting member. The output or tail shaft member *J* of the transmission is fixed to the rotating casing *B* carrying the turbine blades *E*, and torque from the input shaft *C* is transmitted to this member and to the pump wheel *D* through differential gear mechanism. The mechanical functioning of the device will be largely evident from the drawing. Part of the input torque operates the pump to circulate the hydraulic fluid and impose a forward torque on the blades *F* and the casing *B*. Torque in reverse direction is imposed on blades *G*, but the direction of this torque is reversed by the reversing gearing and transmitted to the casing through the freewheel clutch, so that the torques from the two turbine wheels are added and applied to the casing and the tail shaft in the forward direction.—*July* 11, 1951.

Launches and Trial Trips

EASTERN STAR, cargo vessel; built by Harland and Wolff, Ltd., for Common Brothers, Ltd.; length between perpendiculars 435ft, breadth moulded 59ft 9in, depth moulded to shelter deck 38ft 6in; one set of Parsons' triple-expansion, condensing, double-reduction, geared turbines of 7250 s.h.p. at propeller speed of 110 r.p.m., taking steam at 450 lb per square inch and 750 deg. Fah. from two oil-fired single-pass sectional header Babcock and Wilcox boilers. Launch, August 2nd.

ARUSHA, steam tug; built by Henry Robb, Ltd., for the British India Steam Navigation Company, Ltd.; length between perpendiculars 112ft 6in, breadth moulded 32ft, depth moulded to upper deck 13ft 3in; one triple-expansion surface condensing marine engine, by White's Marine Engineering Company, 800 s.h.p. at 180 r.p.m., steam at 200 lb per square inch from one single-ended marine return-tube boiler. Launch, August 17th.

BRITISH TALENT, motor tanker; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the British Tanker Company, Ltd.; length overall 643ft, breadth moulded 81ft, depth moulded 44ft 6in, deadweight 28,100 tons; one set of double-reduction geared turbines of 13,750 s.h.p., taking steam at 456 lb per square inch and 750 deg. Fah. from two Foster Wheeler "D" boilers. Launch, August 17th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Engineers' Guild

Thurs., Sept. 27th.—Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

Incorporated Plant Engineers

Tues., Sept. 4th.—LONDON BRANCH: E.L.M.A., Savoy Hill, W.C.2, "Storekeeping," J. Barrett, 7 p.m.

Thurs., Sept. 6th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "Cutting Tool Dynamometry as an Aid to Machine Tool Maintenance," J. Purcell, 7.30 p.m.

Institute of Road Transport Engineers

Tues., Aug. 28th.—Visit to the works of Vauxhall Motors, Ltd., Luton, Beds, 10.15 a.m.

Institution of Works Managers

Tues., Sept. 4th.—WOLVERHAMPTON BRANCH: Works Visit to Goodyear Tyre and Rubber Company, Ltd., Wolverhampton, and John Thompson (Wolverhampton), Ltd.

Royal Aeronautical Society

Mon., Sept. 10th.—Royal Institution, 21, Albemarle Street, W.1, 39th Wilbur Wright Memorial Lecture, "The Well-Tempered Aircraft," A. E. Raymond, Douglas Aircraft Corporation, 6 p.m.

Thurs., Oct. 4th.—Institution of Civil Engineers, Great George Street, S.W.1, Seventh British Commonwealth and Empire Lecture, "Air Transport in New Zealand and the South Pacific," Air Vice-Marshal Sir L. M. Isitt, R.N.Z.A.F., 6 p.m.

Stephenson Locomotive Society

Sat., Aug. 25th.—Lineside Traffic Observation, Bromsgrove and Lickey Incline, L.M. and W. Regions, from 2 p.m.

Sat., Sept. 1st.—SCOTTISH CENTRE: Tour by special train over routes not usually available for passengers, Paisley—Johnstone—Barrhead. Start Paisley (East Mineral) about 2.45 p.m.

Sat. Sept. 8th to Sun. Sept. 9th.—Week-end tour of Motive Power Depots in Swansea and South Wales area.

Sat., Sept. 15th.—Visit to Ashford Locomotive Works and Running Shed, S.R., from 2.45 p.m.